ARS-BLM COOPERATIVE STUDIES

REYNOLDS CREEK WATERSHED

INTERIM REPORT NO. 3
Cooperative Agreement No. 14-11-0001-4162(N)

For Period July 1, 1971, to December 31, 1972

(NOTE: Generally, a variety of watershed data are compiled on a calendar year basis. However, the water year, beginning October 1 and ending September 30, has proven best for hydrologic comparisons.)

MARCH 1973

TO

Portland Service Center
Bureau of Land Management
U. S. Department of the Interior
Portland, Oregon

FROM

Northwest Watershed Research Center
Western Region
Agricultural Research Service
U. S. Department of Agriculture
Boise, Idaho

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INTRODUCTION

Cooperative watershed research between the Agricultural Research Service, U. S. Department of Agriculture, and the Bureau of Land Management, U. S. Department of the Interior, was initiated in 1968 under Cooperative Agreement No. 14-11-0001-4162(N). Also, the Memorandum of Understanding, dated July 6, 1961, which is a part of the Cooperative Agreement, specifies the overall responsibility of each agency.

This interim report summarizes progress and results to December 31, 1972. Agreement renewals for each fiscal year include the Annual Work Plan and Budget which is prepared and approved by representatives of both agencies.

The major objectives of the research on the Reynolds Creek and Rabbit Creek Watersheds are to provide meaningful data for guidance in planning and implementing a range management and improvement program, and to formulate procedures and models for predicting the effects of management and land-use changes on forage production, water yield, soil erosion, and related resources.

The study watersheds are included within an area in southwest Idaho, which has been classified as needing management attention immediately. Also, portions of the Rabbit Creek Watershed are included in designated "frail lands" areas, considered to be in the most critical condition. The poor condition of much of the area is a result of past abuse by livestock and wildlife, compounded by steep topography, erosive soils, and occasional severe storms. At present, proper grazing management is probably the key to range improvement in the area. However, recreational and other uses may cause different abuses and problems which must be controlled and solved.

The Boise District of the Bureau of Land Management is the administrative office for most of the federal land in Owyhee County, Idaho, where the Reynolds Creek Watershed is located. Therefore, coordination of BLM management activities and ARS research activities has been necessary as fencing, roads, and other facilities have been planned and constructed. A grazing management system is scheduled for the area, including the watershed, beginning in 1973, and opportunities for complementary research are under consideration.

The Water Quality Study was initiated during the reporting period, and this report includes the preliminary results. Also, the study site on Whiskey Hill, Figure 1, was fenced and instrumented.

Details of progress and accomplishments are described in each section of the report. Further information is contained in Northwest Watershed Research Center Annual Reports for 1971 and prior years and in Interim Report Nos. 1 and 2 of ARS-BLM studies in the Reynolds Creek Watershed under Cooperative Agreement No. 14-11-0001-4162(N).

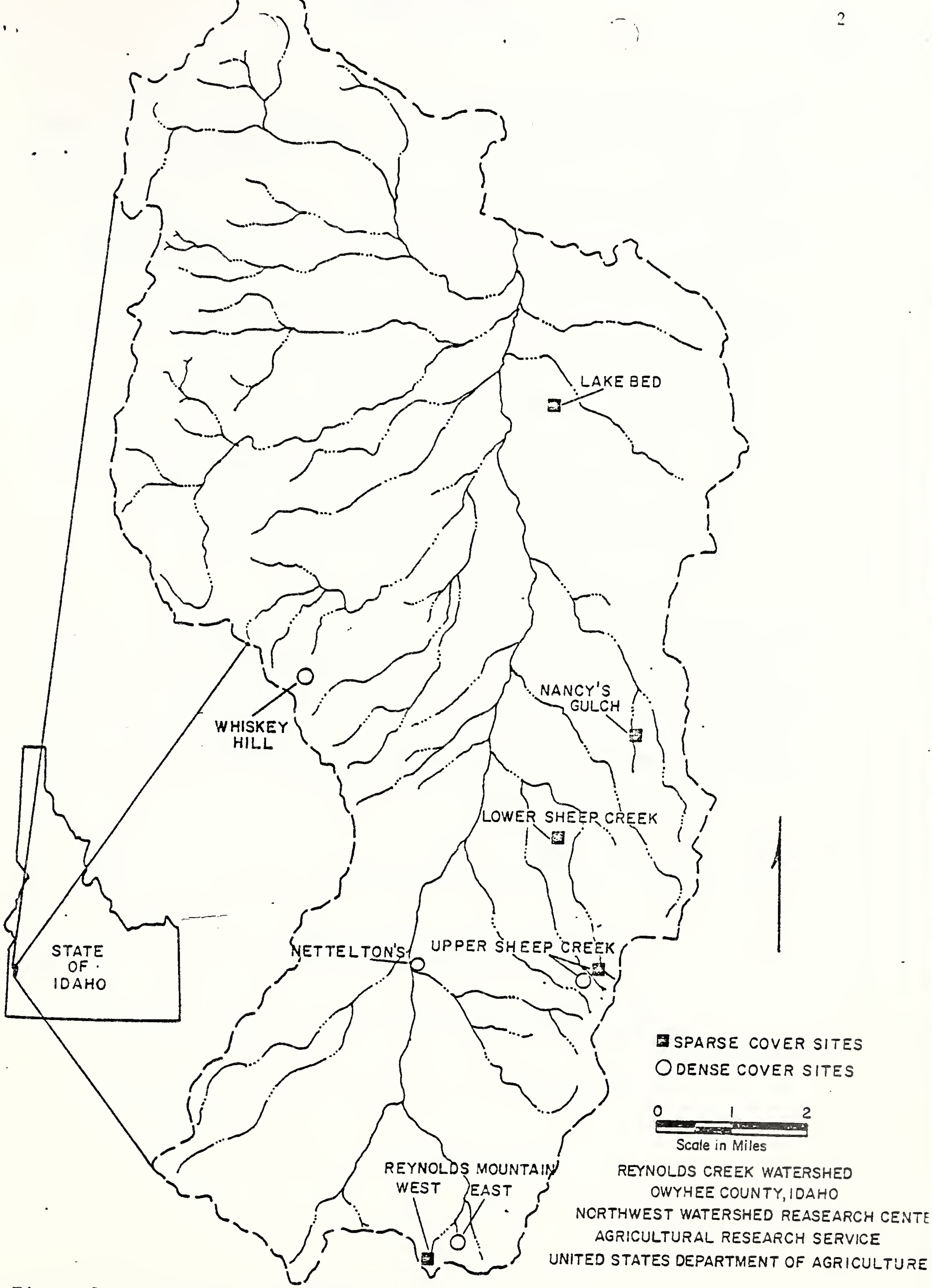

Figure 1. Location of experimental sites.

PART I

Title: Precipitation characteristics of a northern, mountainous, semi-arid watershed

Personnel Involved:

J. F. Zuzel, Hydrologic Technician	Supervise data collection and conduct special analyses requiring the use of a computer.
W. J. Rawls, Hydrologist	Supervise data reduction and conduct special analyses requiring the use of a computer.

Date of Initiation: June 1961

Expected Termination Date:

Field Work - September 1973
Data Reduction - December 1973
Interpretation and Summary of Objectives - June 1974

INTRODUCTION

No dense, recording raingage network existed in the Northwest prior to establishment of the Northwest Watershed Research Center. Such a network is necessary to delineate thunderstorms and storm variability. National Weather Service data collection stations are generally located in or near the main cities. Since these are generally along the main stems of major streams or in valleys, a sample of the range watershed areas is not available from their records. Also, there are too few raingages capable of recording intensities or even individual storm data.

Objectives:

1. To develop methods for evaluating precipitation rates and amounts for watersheds of different sizes.

2. To determine seasonal distribution of precipitation with respect to amounts, character, and areal extent.

3. To develop depth-duration-frequency and depth-area-duration relationships for the Reynolds Creek Experimental Watershed.

4. To establish general precipitation-elevation-aspect-slope relationships from precipitation data obtained in the Reynolds Creek Experimental Watershed.

PROGRESS

Precipitation data collection was continued from the precipitation gage network in the Reynolds Creek Watershed comprised of 49 dual-gage sites (98 gages) and from the Rabbit Creek network comprised of 5 dual-gage sites (10 gages).

Installation of the dual-gage networks began in the fall of 1967. At the same time, a precipitation gage evaluation site was established at Reynolds Mountain. Data from the evaluation site, along with snow pillow and snow course data, have been used to determine the coefficient in the developed mathematical model to compute actual precipitation from the dual-gage data. The experimental determination of this coefficient will now allow for a computation of realistic precipitation data.

Computer programs are in the process of being developed to convert shielded and unshielded precipitation data to actual precipitation. In addition, a program to test the sensitivity of the precipitation model coefficient as it affects average areal precipitation is under development.

SIGNIFICANT FINDINGS

None.

WORK PLAN FOR FY 1974

The sensitivity of the precipitation model coefficient as it affects average areal precipitation will be tested.

All shielded and unshielded precipitation data for the years 1968-1973 will be converted to actual precipitation using the precipitation model.

Computer programs designed to determine precipitation-runoff-sediment relationships for winter runoff events with snowmelt and frozen soil will be developed.

Frequency analysis will be used to determine distribution of precipitation with respect to amounts and areal extent. The practicality of using the ratio between a shielded and an unshielded gage to separate rain from snow will be investigated.

REPORTS AND PUBLICATIONS

None.

PRECIPITATION

PART 2

Title: Evaluation of precipitation gage performance

Personnel Involved:

W. R. Hamon (ARS-Coshocton, Ohio)

Date of Initiation: December 1964

Expected Termination Date: April 1973

INTRODUCTION

Hydrological investigations require the use of precipitation data in evaluating the hydrologic behavior of watersheds where snowfall constitutes the major portion of the precipitation. Water balance computations and snow cover measurements have uncovered serious deficiencies in precipitation measurements by both unshielded and shielded precipitation gages. Shielded gages, however, collected considerable more precipitation than the unshielded gages.

In 1967 a new approach was initiated which involved the use of data from a dual arrangement of an unshielded and shielded gage to compute actual precipitation.

Objectives:

1. To determine which of several commercially available precipitation-measuring devices most accurately measure the actual amount of precipitation.

2. To develop criteria and specifications for installing precipitation gages to provide the most accurate measurements of precipitation.

3. To develop methods and procedures for adjusting records from precipitation gages with "standard" installations to more accurately reflect the point precipitation.

PROGRESS

An analytical model for computing actual precipitation from unshielded and shielded gage data, independent of windspeed and type of precipitation, was derived by use of exponential wind functions to relate the ratios of catch by unshielded and shielded gages to actual precipitation. The single calibration coefficient in the model has been experimentally verified in the

field. The ratios of unshielded and shielded gage catch to actual precipitation were evaluated by use of computed actual precipitation obtained by applying the model as a function of windspeed and temperature.

SIGNIFICANT FINDINGS

1. The analytical model developed for computing actual precipitation from unshielded and shielded (rigid) gage data is essentially independent of windspeed and type or form of precipitation.

2. The single calibration coefficient in the model was experimentally determined to have a value of 1.8 for the type of gage and rigid shield used.

3. The error in precipitation data collected by the unshielded gage is about 15 percent for rain and 30-60 percent for snow at windspeeds of 10 miles per hour, increasing to about 25 percent for rain and 30-80 percent for snow at windspeeds of 20 miles per hour. For the shielded (rigid) gage, these errors are reduced by 50 percent for rain and by 35-45 percent for snow.

4. Storm precipitation can be computed from unshielded and shielded (rigid) gage data with an accuracy of less than 10 percent for snow in the absence of capping, and 5 percent for rain for windspeeds up to 30 miles per hour. This error becomes less as greater amounts of precipitation are collected before performing the calculations.

5. Orifices of the dual gages must be at the same height above ground (no fixed height is required), and the gages should be situated so the airstream is essentially horizontal and uninfluenced by obstructions.

WORK PLAN FOR FY 1974

This investigation has now been completed. Details of the experimental design, data, and conclusions are included in Appendix A of this report.

REPORTS AND PUBLICATIONS

Hamon, W. R. Computing actual precipitation. Presented WMO-IASH Symposium, Geilo, Norway, July-August 1972.

VEGETATION AND SOIL MOISTURE

Title: Evaluation of cover production, herbage yield, and soil conditions for different levels of vegetation management

Personnel Involved:

G. A. Schumaker, Soil Scientist	Plans, designs, and coordinates research activities and prepares reports.
W. J. Rawls, Hydrologist	Prepares computer programs for analysis of vegetation data.
J. F. Zuzel, Hydrologic Tech.	Performs computer analysis relative to soil moisture data.
D. L. Coon, Hydrologic Tech.	Responsible for various aspects of data collection and field observations including soil moisture measurement and calibration; compiles research outline data.

Date of Initiation: May 1971

Expected Termination Date: Field Work - December 1974
Interpretation and Summary - December 1975

INTRODUCTION

Quantitative data on herbage yield from rangelands under different levels of management are needed to guide land managers in coordinated multiple use of the range. These needs require more discerning information on how vegetation and soils respond to imposed treatments, including controlled grazing. Information is also needed with regard to methods of increasing cover and to the rate of recovery of native range following intensive grazing practices.

Objectives:

1. To determine the effect of grazing management and treatments on yield of herbage, cover production, soil moisture regimes, and soil surface conditions at selected sites.

2. To study changes in plant density and plant composition as a result of grazing management and treatments.

PROGRESS

Vegetation and Soils

The 1972 vegetation studies carried out on Reynolds Creek Watershed were done on nine study sites. Eight of the study sites were established prior to the 1972 growing season. The exclosure at the Whiskey Hill site was constructed in June 1972. After the exclosure was fenced, one half of it was sprayed for sagebrush control with a 2,4-D compound at the rate of 1 1/4 pounds active ingredient per acre. Five of the nine study sites at Reynolds have two treatments--a grazed area and an ungrazed area. One site, Whiskey Hill, has three treatments--a grazed area, an exclosure with an untreated area, and a brush-sprayed area. The remaining three study sites have four treatments--a grazed area, an exclosure with an untreated area, a brush-sprayed area, and a brush-removed area. Table 1 gives descriptive information relative to each of the nine study sites.

Vegetation yields were measured on each treatment beginning with the lower study sites early in the growing season and moving to the higher sites as the growing season progressed. All yield data were collected by the double sampling method. A total of ten 9.6-square-foot random plots were clipped to obtain samples on each treatment. Figure 1 is a flow chart of the vegetative sampling and data handling procedure for yield determinations. The numbers in parentheses in the following written description coincide with the numbers on the flow chart in Figure 1.

The first step was to clip (1) a sample plot and weigh (2) and record the green weight by species (3). These three steps were followed on each of the clipped plots. The green weights of the various species from the clipped plots were used in making estimates of the green weights (4) on seven additional sample plots in the treatment area.

The clipped samples were (5) ovendried and then weighed to obtain the ovendried weights (6). The ovendried weights and the green weights from the clipped plots were used to form a ratio (7) of the percentages of moisture in the green vegetation by species. These ratios for individual species were applied to the other green weights of the same species to obtain ovendry weight equivalents (8).

The ovendry weights (9) from the clipped plots and the ovendry equivalents for the estimates (10) were converted to a 12 percent moisture air-dry weight.

The final steps were to average all yields per treatment (11), and then convert this yield to pounds per acre per treatment (12), as shown in Table 2.

The vegetative yields from the study sites having only two treatments, grazed vs. ungrazed (untreated), do not show much difference. It appears that the differences in yield between the grazed and ungrazed portions of these sites are a result of the natural variations at the site and the random method used in selecting the sample plots. A species breakdown

of the yields on these sites indicates that brush species generally contribute more than half of the total vegetation yields (Table 2).

The yield measurements from the multiple treatment study sites showed the effects of the brush on total vegetational yields quite profoundly (Table 2). The total yields from the sprayed and the brush-removed treatments were lower than the yields from the grazed and ungrazed portion of the site; however, yields from the sprayed and brush-removed treatments contained a greater percentage of grasses and forbs than the treatments containing dense brush. The dense vegetation sites within the exclosures showed some increases in herbaceous vegetation on all treatments, probably due to the reduced grazing pressure. These dense vegetation sites are in higher precipitation zones and/or snow drop zones, with the exception of the Nettleton's study site, and respond more rapidly to reduced grazing pressures than the sparse vegetative sites.

The vegetative yields appear to reflect the differences in precipitation. As the elevation increases, the amount of precipitation is usually higher and in most all cases there is an increase in vegetative yields. The exceptions to this rule are the Upper Sheep sparse vegetation site, the Lower Sheep site, and the Reynolds Mountain sparse vegetation site. The vegetative yields on these sites reflect the moisture deficiency of the south and west exposures where strong winds remove the snow (Tables 2 and 3).

Average 1972 yields at several of the study sites were less than those measured in 1971. For instance, 809 pounds per acre were measured on the Upper Sheep Creek dense vegetation sprayed site in 1972, while the same site showed a yield of 2,933 pounds per acre in 1971. A later harvest date in 1972, after seed heads had matured and seed drop had occurred, could in part explain the lower yields. Further investigations are underway to determine reasons for the differences in the two years' data at the various sites.

A 700-point transect was taken on each treatment at each site during the 1972 growing season. These transects consisted of seven 100-point transect lines taken 10 feet apart. If the exclosure was too small to allow 100 points to be taken in one line, then the lines were taken at closer intervals than 10 feet to allow a total of 700 points on each treatment. The points were taken with a four-spoked wire wheel with the spokes about 2 feet from point to point (Figure 2). This device permitted transect points to be taken in a line even when working in dense tall sagebrush. The first material the point of the spoke intercepted in its downward arc was taken as the overstory, and all other objects were noted as understory.

At the Nettleton's site a comparison between the transects before and after grazing showed that the vegetation cover decreased with grazing but the amount of litter increased (Table 4). This was primarily due to the amount of vegetation knocked down and broken off by trampling of the cattle. This data did not attempt to measure utilization by livestock, but measured changes in cover due to grazing.

On the study sites receiving multiple treatments there were increases in herbaceous vegetation after spraying or removing brush. This increase is

not clearly shown in Table 4, particularly on the brush-sprayed treatments, because the point of the sampler wheel spoke, used to obtain the transect data, struck the dead stems of the sprayed brush first, thus indicating persistent litter in the overstory.

Overall, the cover measurements indicate that the sparse vegetation sites are responding to the various treatments rather slowly as compared to the dense vegetation sites where there have been notable increases in herbaceous vegetation. The amount of herbaceous vegetational recovery is primarily related to the microclimate of the study site.

A series of photographs were taken on each of the micro-plots through the growing season to depict changes that occur in growth and maturity of the plants. The initial basal area measurements for the Reynolds Mountain sparse vegetation site were completed in 1972. Also, basal area measurements within the exclosure were completed on the Lower Sheep Creek study site. Time did not permit initial basal area measurements on the Whiskey Hill study site in 1972.

An evaluation of the erodibility of the nine sites was completed in May and June, using the SSF (soil surface factor)[1/] rating sheet. The ratings were not significantly different from values recorded in 1971. The new study site at Whiskey Hill was given a stable rating.

Soil Moisture

Accurate measurement of soil water in the field is a necessity in plant-soil-water research. Such measurements can be obtained by the neutron method, which is now considered by many to be the most reliable and efficient. Proper field calibration of neutron-measuring equipment is essential for its successful use. Field data for calibration of a neutron soil moisture probe (Troxler[2/] model 200-B scaler and model 104-A depth probe with a 100 mc. 241 Am-Be neutron source) were collected from five areas of Reynolds Creek having a network of access tubes. The procedure used for field calibration was to relate the volumetric soil-water measurement to the ratio of neutron probe counts and standard counts. One-minute neutron probe counts were taken at 6-inch intervals to a depth of 36 inches except where soil profiles were less than the 36-inch depth due to bedrock. Bulk density samples and soil moisture samples were taken in 3-inch increments to a depth 3 inches below the lowest depth of measurement with the neutron probe. Percent water by volume for the individual samples was determined from the gravimetric soil moisture and bulk density values. A single volumetric soil water value, comparable to each neutron probe reading, was determined by averaging volumetric data for a 6-inch thick soil layer whose center was the same depth.

1/ BLM form used in range surveys.

2/ The citation of particular products or companies is for the convenience of the reader and does not imply any endorsement, guarantee, or preferential treatment by the U. S. Department of Agriculture or its agents.

Analysis of the calibration data from the five areas has not been completed; however, a preliminary analysis of the Summit data has been completed and illustrates the need for field calibration. Soil-water values obtained from the calibration curve provided by the manufacturer were compared with values determined volumetrically (Figure 3). Errors ranged from 2.3 to 10.0 percent with an average error of 5.9 percent. Since the instrument manufacturers' calibration curve could not measure absolute soil water or changes in soil water within the acceptable range of plus or minus 4.0 percent, an attempt was made to develop a field calibration curve. A linear curve was developed using least squares relating the ratio of neutron probe counts and standard counts to volumetric soil moisture values. This fitting gave a correlation coefficient of 0.85 and a standard error of estimate of 3.4 percent. This curve is presented in Figure 3. The errors ranged from 0.1 to 5.4 percent, with an average error of 2.1 percent.

The above analysis illustrates the need to develop a field calibration curve for use with a neutron probe for measuring soil moisture in Reynolds Creek Watershed.

Soil moisture was monitored throughout the growing season at Upper Sheep Creek and Reynolds Mountain brush treatment sites. The treatments consisted of complete removal of Artemesia tridentata, chemical treatment with 2-4,D, and no treatment for a natural control. Figure 4 illustrates the cumulative moisture loss for the various treatments for the top 4 feet of soil during the growing season at Reynolds Mountain study site. As can be seen in Figure 4, the sprayed treatment had less evapotranspiration loss throughout the season than no-brush treatment. A greater amount of soil moisture was lost from the brush-removed treatment through July. Complete removal of the brush permitted greater air movement over the surface and greater exposure to radiation. Moisture loss was markedly less on this treatment during August and September when the grasses had matured. In comparing the brush-removed and sprayed treatments very little difference was noted in total moisture removed from the 4-foot profile during the season although the rate of use was different during the season, Figure 4. The deeper rooted, big sagebrush continued to extract moisture from the profile throughout the season resulting in a loss of 5.7 inches of water during the period June 6 through September 28. Loss from the sprayed treatment was 4.8 inches for the same period. Since only limited soil moisture data has been collected on the brush-treatment sites on Reynolds Creek, it is too early to draw definite conclusions about the moisture regimes for the different brush treatments.

The time at which maximum soil moisture storage occurs and the rate of seasonal soil moisture depletion are useful hydrologic information for management of rangelands. In 1966 and 1967 three intensive networks of soil moisture access tubes were established. These networks were located to cover a range of soils, elevations, and precipitation zones, as can be seen in Table 5. Predominantly, the precipitation pattern is rain at the low elevations and snow at the high elevations.

These networks have been monitored approximately biweekly with a neutron soil moisture probe. From this data, an average annual soil moisture curve

for the top 3 feet of soil was developed for each area. The curves are given in Figure 5, 6, and 7. These curves demonstrated that maximum soil moisture accumulation occurs in late February for the low elevations and late May for the high elevations. The minimum soil moisture occurs in July and August. Maximum soil moisture accumulation varied from 8 to 18 inches of water. The depletion rate between the minimum and maximum soil moisture was approximately linear with a total depletion of 2.5 to 4 inches of water.

SIGNIFICANT FINDINGS

Results of the shrub-grass vegetational sampling on the Reynolds Creek Watershed show a predominance of shrub species.

Dense vegetative sites seem to respond rapidly to any type of brush control, both in terms of yields of understory grasses and vegetative cover of herbaceous plant material. The sparse vegetational sites have reacted very slowly to the various treatments, mainly because of lower precipitation or snow removal by wind. Also, significant improvement in cover requires more than 2 or 3 years of non-grazing on these harsher sites.

Preliminary analysis indicates that field calibration is necessary in order to use a neutron soil moisture probe to measure soil moisture in Reynolds Creek.

Results of studies conducted in 1972 show that, where Artemesia tridentata was treated with 2-4,D, moisture loss from the soil profile seemed to be different from that where Artemesia tridentata remained.

Long-term soil moisture trends for various rangeland conditions were determined. This data indicates that maximum soil moisture occurs in late February for low elevations and late May for high elevations. The minimum soil moisture occurs in July and August.

WORK PLAN FOR FY 1974

Yield and vegetative cover data collected in the field will be related to management treatments imposed on sites representing different ecological zones at Reynolds Creek.

Cooperative work will be carried out with District BLM in selecting sites and in measurement of vegetative composition and vigor in areas where rotation grazing has been implemented on Reynolds Creek Experimental Watershed.

Procedures for making ground cover and herbage yield measurements will be established.

Measurement of changes in species composition, cover, herbage yield, soil moisture, and soil conditions for different vegetative management practices

will be continued. Emphasis will be given to measurement of herbage yield, notation of cover change, and measurements of changes in plant vigor on the different sites.

- Field calibration of the neutron probe will be completed.

REPORTS AND PUBLICATIONS

None.

Table 1. Tabulation of site information

SITE	ELEVATION (feet)	SLOPE 2/ (percent)	ASPECT OF SLOPE	PRECIPITATION 2/ (inches)	SOIL SERIES 2/	VEGETATIVE 2/ COVER (percent)	SCS HYDROLOGIC CLASSIFICATION
SPARSE VEGETATION SITES							
Flats	4000	5	North	9	Nannyton loam	<25	B
Nancy's Gulch	4600	8	Northeast	13	Glasgow loam	<25	C
Lower Sheep Creek	5400	16	Northwest	16	Searla gravelly loam	<25	B
Upper Sheep Creek	6100	25	Southwest	22 3/	Gabica cobbly gravelly loam	<25	D
Reynolds Mountain West	6850	5	Southwest	32 3/	Bullrey gravelly loam	<25	B
DENSE VEGETATION SITES							
Nettleton's 1/	5000	25	West	21	Reywat-Bakeoven rocky very stony loam	>50	D
Reynolds Mountain East	6800	6	Northwest	32 4/	Bullrey gravelly loam	>50	B
Upper Sheep Creek	6100	33	Northeast	22 4/	Harmehl and Demast loam	>50	C
Whiskey Hill	5550	15	East	17	Takeuchi rocky coarse sandy loam	50	B

1/ Good grass cover site on soil developed from basalt. Another site will be located on a soil developed from granite.

2/ Tentative

3/ Snow removed by wind

4/ Snow deposition zone

TABLE 2.--Vegetative yields from the various treatments at the different study sites on Reynolds Creek Watershed for the 1972 growing season[1/]

Site	Grazed		Exclosure					
			Untreated		Brush-sprayed		Brush-removed	
	Brush	Other[2/]	Brush	Other	Brush	Other	Brush	Other
	Lb/acre		Lb/acre		Lb/acre		Lb/acre	
Flats (sparse vegetation)	456	207	207	216				
Nancy's (sparse vegetation	230	151	334	166	142	331	42	256
Lower Sheep (sparse vegetation)	362	155	216	148				
Whiskey Hill (dense vegetation)	655	246	640	262	121	187		
Nettleton's (dense vegetation)	172	339	179	383				
Upper Sheep (sparse vegetation)[3/]	209	165	287	110				
Upper Sheep (dense vegetation)	707	478	722	357	33	776	68	979
West Reynolds Mtn. (sparse vegetation)[4/]	176	300	221	99				
East Reynolds Mtn. (dense vegetation)	961	232	830	502	0	801	16	746

1/ Yield averages were derived from the double sampling method and are expressed as pounds air-dry plant material per acre.

2/ Other includes total yield of all grasses and forbs species.

3/ South exposure.

4/ West exposure and subject to high winds.

TABLE 3--Comparison of the 6-year average (1967-1972) with the 1971 and 1972 precipitation total from vegetation study sites on Reynolds Creek Watershed

Site	Rain Gage No.	Elevation of Rain Gage	Year	Precipitation[1/] March-July	Precipitation[1/] Annual Total
		Ft.		In.	In.
Flats	057496	3,885	1971	4.49	10.47
			1972	3.12	8.48
			Average[2/]	3.49	8.98
Nancy's	108404	4,810	1971	5.19	11.01
			1972	3.27	8.96
			Average	3.99	10.77
Lower Sheep	127407	5,410	1971	5.81	13.44
			1972	3.28	10.22
			Average	4.18	11.53
Whiskey Hill	095410	4,880	1971	8.97	20.67
			1972	7.07	20.49
			Average	5.78	17.36
Nettleton's	116491	4,770	1971	8.18	19.30
			1972	5.91	18.80
			Average	5.48	16.23
Upper Sheep	147435	6,140	1971	7.43	13.44
			1972	3.23	12.34
			Average	5.30	14.41
Reynolds Mtn.	176407	6,800	1971	11.26	34.19
			1972	8.03	27.99
			Average	8.61	28.83

1/ Data for water year (Oct. 1-Sept. 30) from unshielded rain gages with orifices at 10 ft.

2/ Average for the year 1967-1972.

TABLE 4. Cover measurements on Reynolds Creek vegetational study sites for 1972

Site and Treatment	Vegetation	Litter	Large Rock	Small Rock	Total	Bare Groun
	----------	----------	Percent	----------	----------	----------
FLATS						
Grazed	59.6	9.4	0.3	9.6	78.9	21.1
Exclosure	65.3	8.6	0.9	6.5	81.3	18.7
NANCY'S						
Grazed	50.8	17.9	5.1	14.1	87.9	12.1
Exclosure brush removed	40.6	20.3	5.0	13.1	79.0	21.0
Exclosure sprayed	41.4	24.3	4.0	15.9	85.6	14.4
Exclosure untreated	49.7	14.6	2.6	15.8	82.7	17.3
LOWER SHEEP						
Grazed	55.4	12.00	5.3	19.7	92.4	7.6
Exclosure	59.6	11.1	4.4	17.3	92.4	7.6
NETTLETON'S						
Grazed (before grazing)	64.0	15.4	1.6	7.9	88.9	11.1
Grazed (after grazing)	54.8	24.7	3.4	10.0	92.9	7.1
Exclosure	69.8	17.7	2.6	4.3	94.4	5.6
WEST REYNOLDS MTN.						
Grazed	62.6	8.0	0.6	22.7	93.9	6.1
Exclosure	57.4	7.2	1.9	30.1	96.6	3.4
WHISKEY HILL						
Grazed	65.5	15.4	0.4	8.4	89.7	10.3
Exclosure untreated	65.0	17.6	0.8	8.3	90.9	9.1
Exclosure sprayed	23.2	55.3	0.4	10.7		10.4
EAST REYNOLDS MTN.						
Grazed	77.1	15.7	0.0	2.3	95.1	4.9
Exclosure sprayed	35.3	53.4	1.6	3.6	93.9	6.1
Exclosure untreated	82.1	~~12.4~~	0.9	2.0	97.4	2.6
Exclosure brush removed	73.5	14.0	1.0	4.6	93.1	6.9
UPPER SHEEP SO. FACING SLOPE						
Grazed	44.8	8.7	10.0	22.6	86.1	13.9
Exclosure	56.4	8.7	6.6	20.6	92.3	7.7
UPPER SHEEP NO. FACING SLOPE						
Grazed	80.9	16.3	0.3	0.4	97.9	2.1
Exclosure sprayed	53.7	41.6	0.7	0.4	96.4	3.6
Exclosure untreated	83.2	15.0	0.0	0.1	98.3	1.7
Exclosure brush removed	80.0	11.7	0.3	1.6	93.6	6.4

1/ Table 4 is based on overstory measurements. Understory data is not included.

Table 5.—- Characteristics of Soil Moisture Networks

Location	Average Elevation	Average Annual Precipitation (1965-1972)	Great Soils Group	Flora Association
	Ft.	In.		
Summit	4,355	8.89	Sierozem	Sagebrush Cheatgrass
Lower Sheep	5,420	10.47	Brown-Chestnut	low Little Sagebrush
Reynolds Mt.	6,800	25.15	Brunizem	Sagebrush Lupine

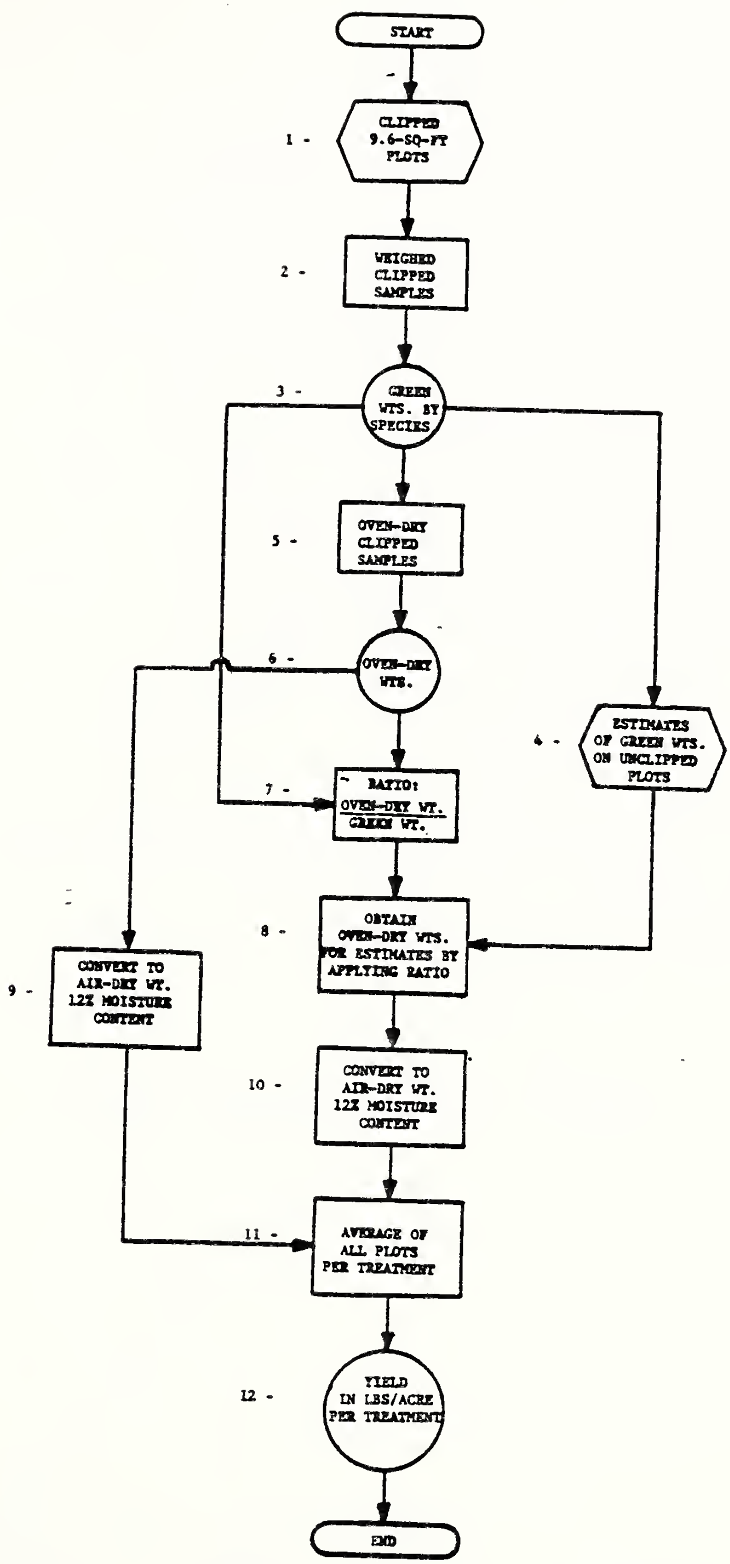

Figure 1. Flowchart of vegetation sampling.

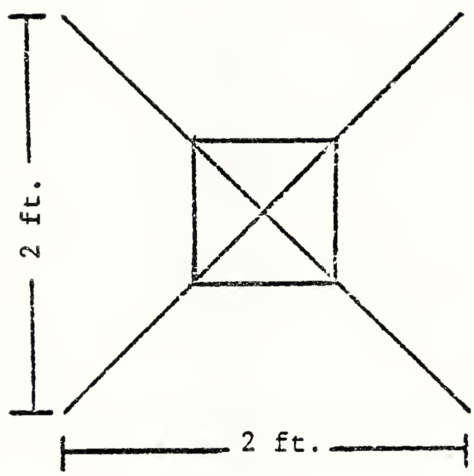

Figure 2. Wheel for taking transects.

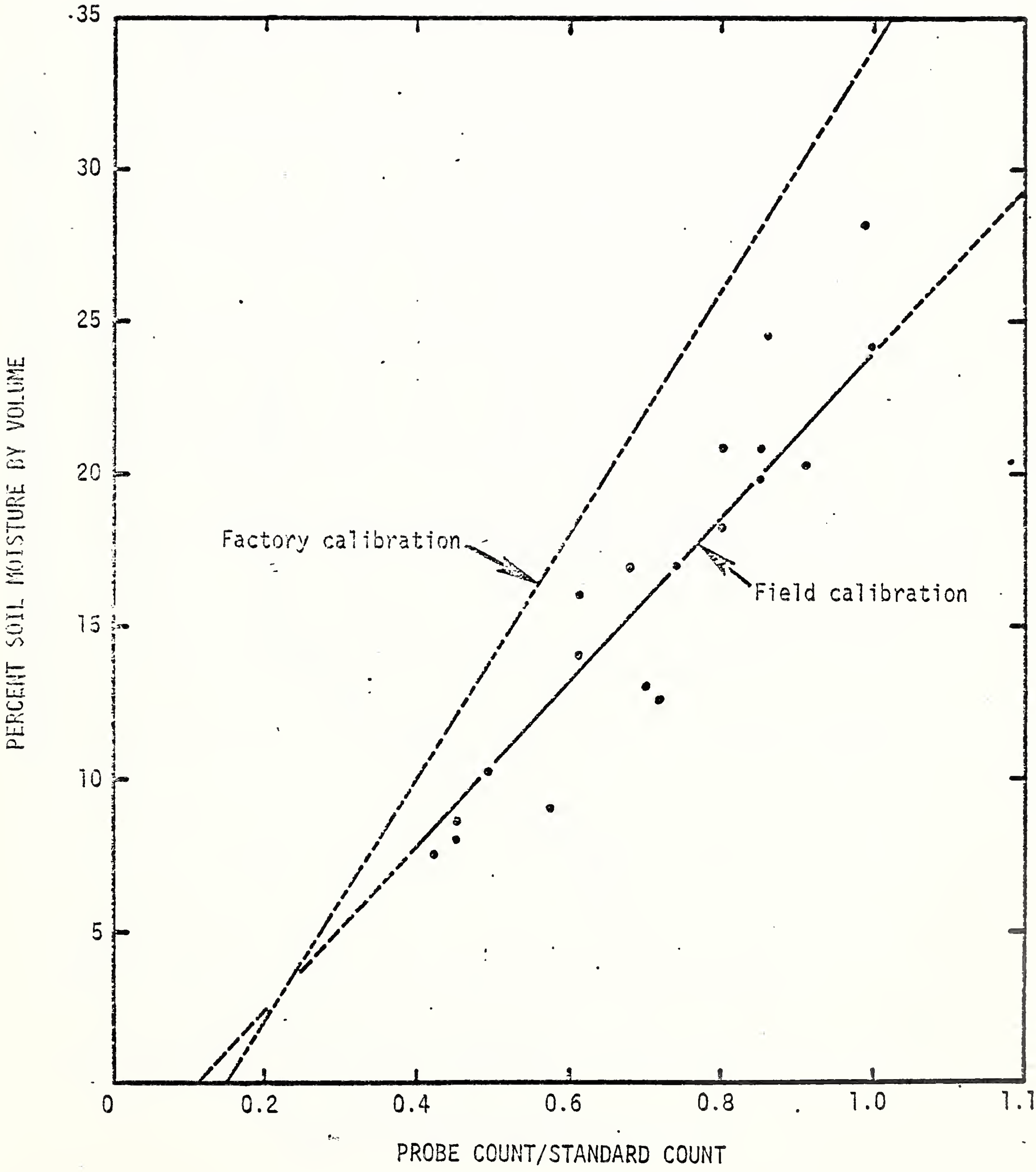

Figure 3. Calibration curves.

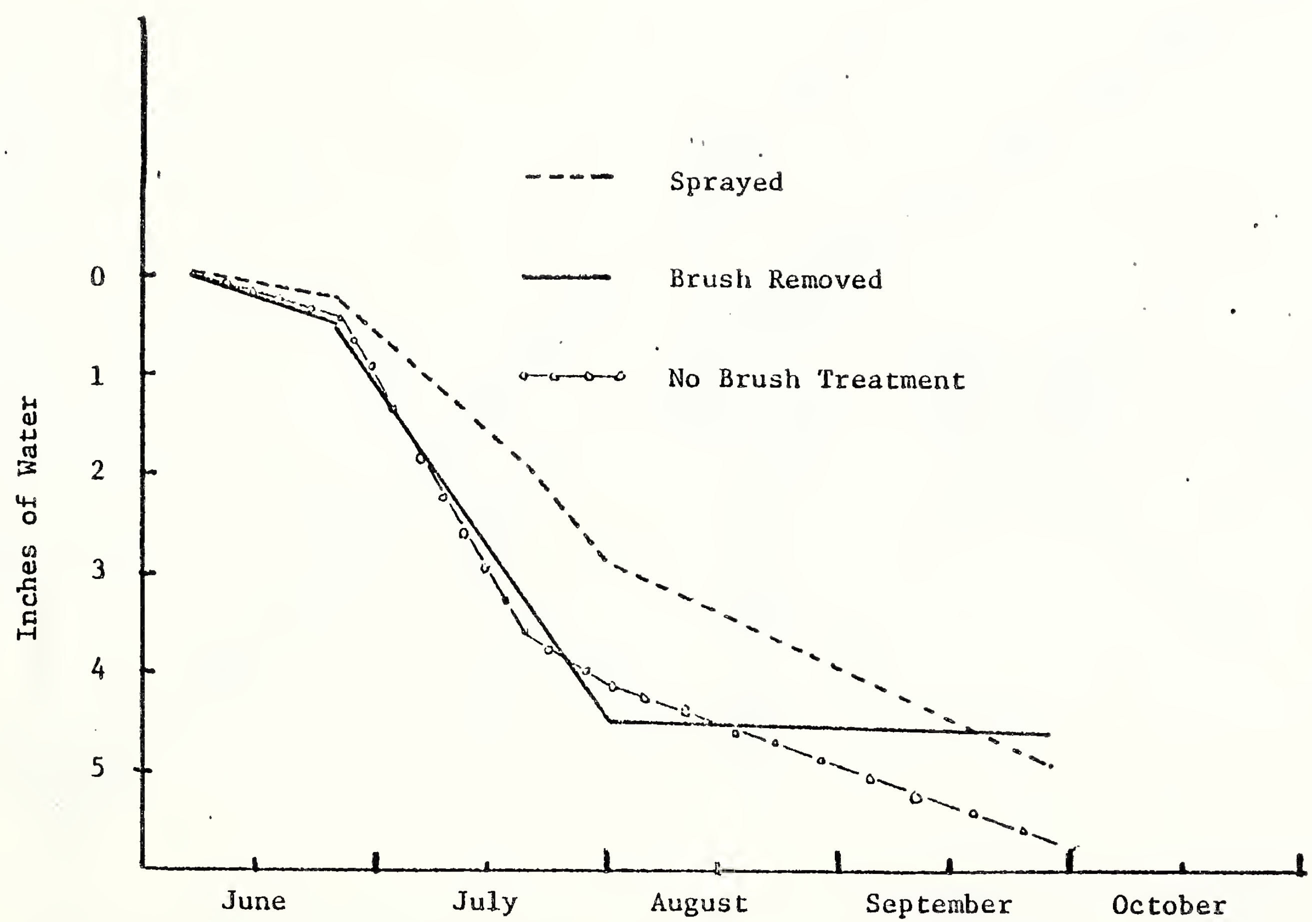

Figure 4. Moisture loss from the soil profile (inches) under different type of brush treatment at Reynolds Mountain exclosure in 1972.

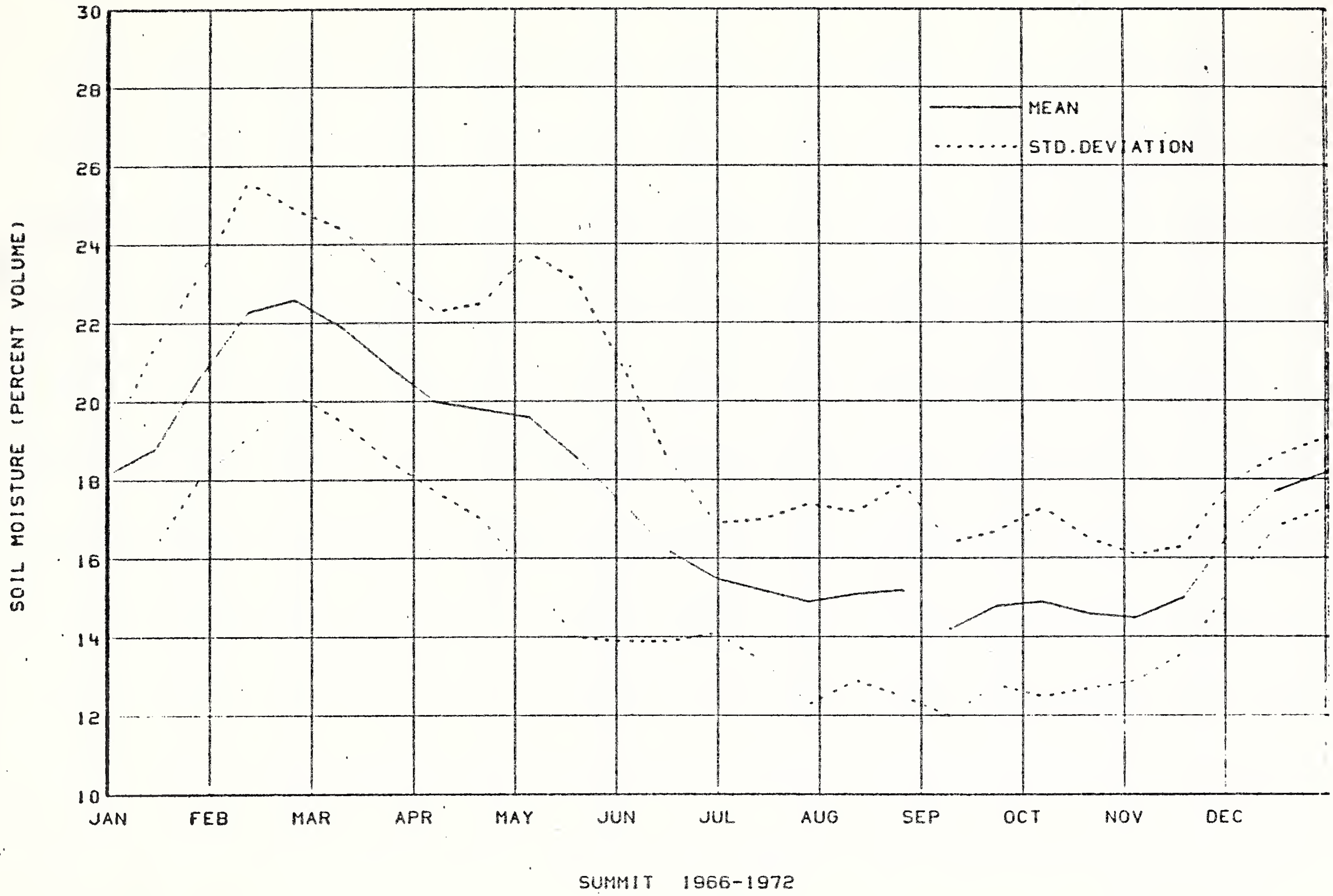

Figure 5. Average soil moisture curve for Summit.

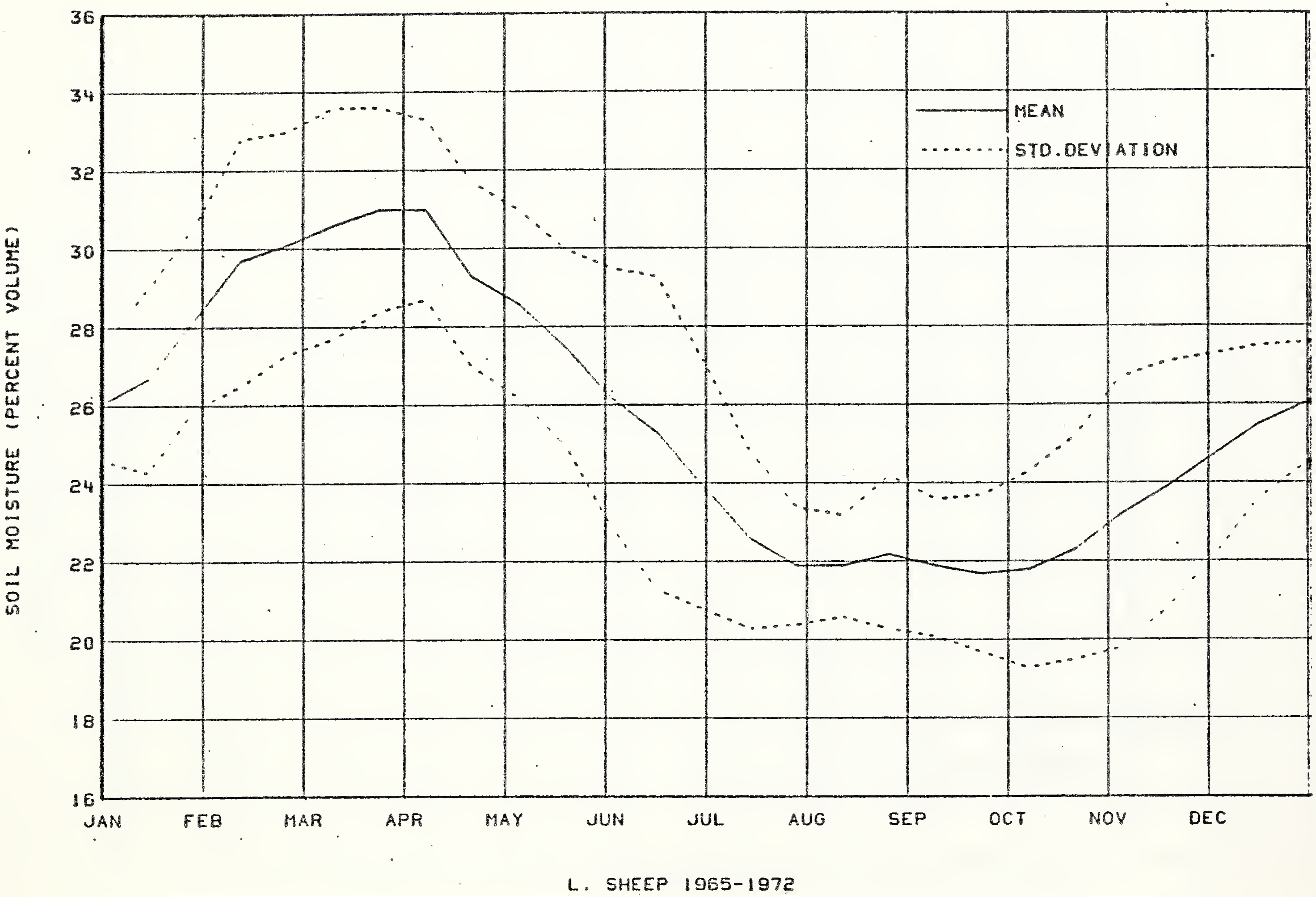

Figure 6. Average soil moisture curve for Lo[illegible] Sheep.

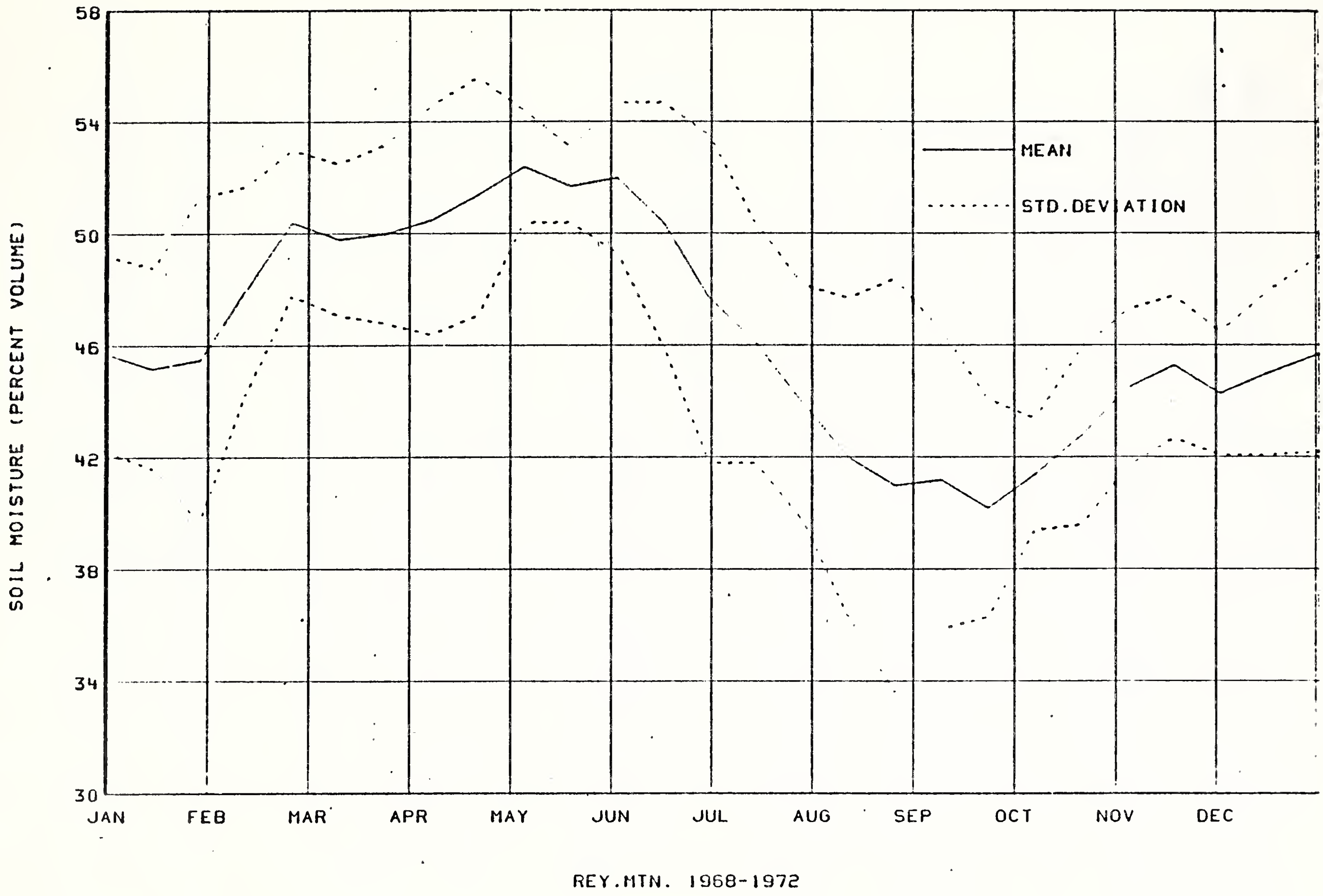

Figure 7. Average soil moisture curve for Reynolds Mountain.

INFILTRATION

Title: Developing, testing, and evaluating an analytical infiltration model

Personnel Involved:

W. J. Rawls - (ARS-Boise)	Supervise field data collection; coordinate the research with the cooperators; perform any other analysis needed.
G. A. Schumaker - (ARS-Boise)	Collect necessary soils and vegetation data.
W. R. Hamon - (ARS-Coshocton, Ohio)	Coordinate the 5-year technical bulletin on infiltration work performed at Boise.
R. W. Jeppson - (Utah State University)	Develop and field test analytical infiltration models.
R. H. Brooks - (Oregon State University)	Assess soil properties in laboratory and in the field; help establish field procedures; help develop and field test analytical infiltration models.

Date of Initiation: February 1971

Expected Termination Date: Field Work - November 1974
Laboratory - September 1972
Interpretation and Summary - December 1974

INTRODUCTION

Infiltration of water into soil profiles is probably the most critical hydrologic component in watershed management, overland flow prediction, sediment generation, natural and artificial ground-water recharge, and irrigation. More accurate information concerning the flow system resulting from infiltration is essential if agricultural lands are to be managed for optimum multiple use. The Northwest Watershed Research Center has been conducting an infiltration research program aimed at developing, testing, and evaluating analytical infiltration models.

Objectives:

1. To develop or adapt mathematical models in the form of partial differential equations to describe steady-state and transient one-dimensional and three-dimensional axisymmetric flow through partially saturated soils.

2. To use mathematical models to adjust for the lateral "spreading effect" of moisture movement from a circular rainfall simulator under various

soil types and conditions.

3. To test and refine the mathematical models by comparing results with laboratory and field determinations of infiltration, and to establish the relative influence of the several interacting physical processes on infiltration.

4. To determine the saturation-pressure relationship (moisture characteristic) and saturated conductivity parameters by the use of parameter optimization in conjunction with the mathematical models and infiltration data.

5. To determine the potential quantity of water retainable by various soil-vegetation complexes independent of infiltration and different initial soil moisture levels.

Mathematical models of steady and transient one-dimensional and three-dimensional axisymmetric flow through partially saturated soils have been formulated by R. W. Jeppson of Utah State to satisfy objectives No. 1 and 2. The collection of the field data to satisfy objectives No. 3, 4, and 5 was performed in the summer of 1972 and will be analyzed during 1973.

PROGRESS

Three general areas in Reynolds Creek were chosen for the infiltration study during the summer of 1972. The infiltration plots were chosen in intensive research areas that exhibited typical soil and vegetation. For replication purposes, two plots were chosen at each site and their identifications and locations are shown in Appendix B.

The portable rainfall-simulator gamma-probe infiltrometer shown in Figure 1 was used to control surface applications of water for determining hydraulic properties of soils <u>in situ</u>. A gamma-ray probe was used to measure the water movement and water content of the soil during applications of water on the surface, and three individual tensiometers were installed under the rainfall simulator adjacent to the gamma-ray probe to provide data on capillary pressure during infiltration.

The field data collection procedure was divided into three runs. Initial and final soil moisture profiles were determined for all runs with the gamma probe:

<u>First Run</u>: Simulated rainfall was applied at an intensity that would not produce runoff. The intensities ranged from 0.5 to 0.7 inch/hour. This run was continued until the wetting front reached a depth of 12 inches or greater. Capillary pressure was monitored continuously at the 2-, 4-, and 8-inch depths in the profile, in conjunction with monitoring of the moisture movement. The plot was allowed to dry for 2 or 3 days after the first run; and, during this time, a border and runoff collector were installed.

<u>Second Run</u>: Simulated rainfall was applied at an intensity of 2.0 to 2.5

inches/hour so that runoff was produced. The rainfall was continued until the runoff rate became constant. Usually this run lasted between 2 and 3 hours.

Third Run: Before the third run, the plot was thoroughly wet (near saturations at the 2-inch depth). After the surface and vegetation were visually dry, 2 inches of rainfall were applied at the following rates, with a 45- to 50-minute drying period between each application:

1. 2 inches/hour for 60 minutes,
2. 2.67 inches/hour for 45 minutes,
3. 4 inches/hour for 30 minutes,
4. 8 inches/hour for 15 minutes.

The preceding three runs were performed on each plot, and the important data are summarized in Table 1. A listing of the data where runoff was produced is given in Appendix B. The data shown in Appendix B is raw data, and a thorough analysis of it is now being performed and will be completed in 1973.

SIGNIFICANT FINDINGS

Procedures and field equipment for collecting infiltration data in the field were perfected. Also, infiltration data from three rangeland sites were successfully collected.

WORK PLAN FOR FY 1974

More field and laboratory data will be collected (if necessary) on rangeland sites to evaluate mathematical models describing steady-state, transient one-dimensional, and three-dimensional axisymmetric flow through partially saturated soils. The relative influence of the physical processes on infiltration will be studied using optimization, and the above infiltration models will be field verified. A technical bulletin summarizing all the infiltration work at Boise will be completed.

REPORTS AND PUBLICATIONS

Jeppson, R. W. Numerical solutions of the steady-state two-dimensional flow system resulting from infiltration on a watershed. Utah State Univ., Logan, PRWG-59c-1, June 1969.

Jeppson, R. W. Transient flow of water from infiltrometers - formulation of mathematical model and preliminary numerical solutions and analysis of results. Utah State Univ., Logan, PRWG-59c-2, June 1970.

Jeppson, R. W. Formulations and solution of transient flow of water from an infiltrometer using the Kirchhoff transformation. Utah State Univ., Logan, PRWG-59c-3, July 1970.

Jeppson, R. W. Determination of hydraulic conductivity-capillary pressure relationship from saturation-capillary pressure data from soils. A description of a computer program for numerically evaluating the Burdine integrals. Utah State Univ., Logan, PRWG-59c-4, July 1970.

Jeppson, R. W. Solution to transient vertical moisture movement based upon saturation-capillary pressure data and a modified Burdine Theory. Utah State Univ., Logan, PRWG-59c-5, Dec. 1970.

Jeppson, R. W. Relationships of infiltration characteristics to parameters describing the hydraulic properites of soils. Utah State Univ., Logan, PRWG-59c-7, June 1972.

Jeppson, R. W. Limitations of some finite difference methods in solving the strongly nonlinear equation of unsaturated flow in soils. Utah State Univ., Logan, PRWG-59c-8, Sept. 1972.

Nelson, R. W. and R. W. Jeppson. Theoretical and experimental aspects of watershed infiltration in terms of basic soil properties. A research and development planning survey. Computer Sci. Corp., Richland, Wash. CSC 6810-1, Oct. 1968.

Wei, Chi-Yuan, and R. W. Jeppson. Finite difference solutions of axisymmetric infiltration through partially saturated porous media. Utah State Univ., Logan, PRWG-59c-6, April 1971.

TABLE 1.--Summary of Infiltration Data

Soil Series	Cover Conditions: Vegetation (%)	Cover Conditions: Litter (%)	Cover Conditions: Rock (%)	Cover Conditions: Bare (%)	Plot No.	Pressure Saturation Data, Depth below Surface: 2"	Pressure Saturation Data, Depth below Surface: 4"	Pressure Saturation Data, Depth below Surface: 8"	Run No.	Soil Moisture: Initial Depth 0-24" (inches)	Soil Moisture: Final Depth 0-24" (inches)	Total Length of Applied Rainfall (minutes)	Time from Start of Applied Rainfall to Start of Runoff (minutes)	Rainfall Intensity (in./hr.)	Total Volume of Runoff for Event (inches)	Final Infiltration Rate (in./hr.)	Time Between Applied Rainfall Events (minutes)
Nannyton Loam	40.2	29.1	1.3	29.4	68057396	X	X	X	5	6.36	9.04	135	12	2.00	2.03	0.80	
									6	8.35	9.42	60	2	2.00	1.33	0.60	50
									7	9.42	9.77	30	2	4.00	1.34	1.10	50
									8	9.77	9.88	20	1	6.00	1.55	0.41	50
									9	9.88	9.88	40	2	3.00	1.52	0.60	
Nannyton Loam	14.6	2.2	12.6	70.6	68057196	X	X	X	4	6.48	7.90	136	6	2.00	3.60	0.50	
									6	7.75	8.26	60	3	2.00	1.69	0.40	50
									7	8.26	8.40	45	3	2.67	1.73	0.37	
Babbington Loam	35.6	38.7	1.0	24.6	68098Y97	X	X	X	3	3.18	5.45	131	10	2.50	2.97	0.57	
Babbington Loam	39.3	10.4	15.4	34.9	68098Z97	X	X	X	2	7.08	8.54	135	8	2.00	1.62	0.80	
									6	7.87	8.16	60	5	2.00	1.12	0.80	50
									7	8.16	8.38	45	4	2.67	1.32	0.67	50
									8	8.38	8.78	30	3	4.00	1.47	0.40	50
									9	8.78	9.05	15	2	8.00	1.59	0.60	
Searla Gravelly Loam	42.7	13.3	38.2	5.8	68127F07	X	X	X	2	7.44	8.88	180	5	3.00	4.35	1.20	
									6	9.14	9.28	60	7	2.00	1.06	0.80	50
									7	9.28	9.28	45	4	2.67	1.08	0.87	50
									8	9.28	9.28	30	3	4.00	1.18	0.63	50
									9	9.28	9.28	15	1	8.00	1.23	2.70	

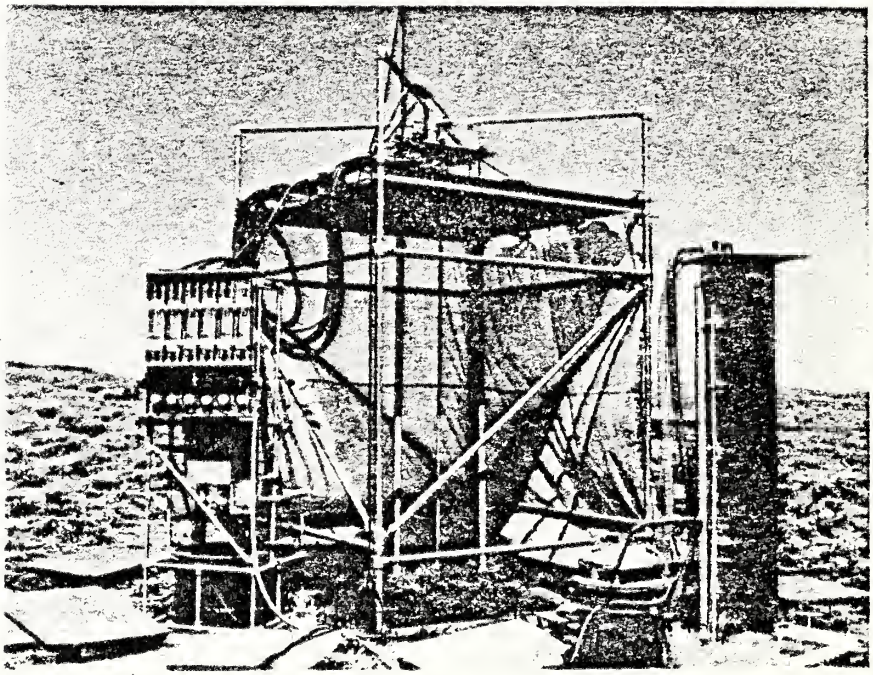

Figure 1.--Picture of Rainfall Simulator

EVAPOTRANSPIRATION

Title: Natural evaporation from sagebrush rangelands, alfalfa, and stock ponds in a semiarid environment.

Personnel Involved:

L. M. Cox (ARS-Boise)	Coordinate the reporting of the experimental data.
W. R. Hamon (ARS-Coshocton, Ohio)	Analyze and report on experimental data.
G. H. Belt (University of Idaho)	Analyze and report on experimental data.

Date of Initiation: November 1968

Expected Termination Date: November 1973

INTRODUCTION

A complete understanding of the evaporative process is essential for developing predictive relationships for the evapotranspiration component for definable soil vegetation complexes under a particular level of management. The Northwest Watershed Research Center, in cooperation with the Department of Forestry, University of Idaho, has been conducting evapotranspiration studies that were designed for measuring and predicting evapotranspiration under sparse vegetative cover and unsaturated surfaces.

Objectives:

1. To determine the evaporative loss of water from sagebrush rangelands, irrigated alfalfa, and stock ponds, while observing pertinent meteorological parameters and the soil moisture status.

2. To develop, for predictive purposes, relationships for associating the evaporative loss with meteorological parameters, type and degree of surface cover, soil moisture, and potential evaporative demand.

PROGRESS

Profile micrometeorological data obtained over irrigated alfalfa and over dryland sites with sparse covers of sagebrush and greasewood were utilized to determine the Bowen ratio and the surface and aerodynamic resistances. The surface resistance was found to be proportional to the Bowen ratio and the proportionality coefficient, a bulk surface resistance parameter, was

dependent upon the availability of water for the evaporation process. This resistance representation of the Bowen ratio was combined with the aerodynamic and energy budget equations to obtain an energy balance-resistance model to compute evapotranspiration and near surface temperature by use of an iterative procedure. The data required consists of air temperature and humidity, windspeed, surface roughness, and an estimate of the bulk surface resistance parameter. This parameter was incorporated into a combination equation, and computed values of evapotranspiration were compared with those obtained by the energy balance-resistance model.

SIGNIFICANT FINDINGS

An energy balance-resistance model for computing evapotranspiration was developed by using profile micrometeorological data obtained over irrigated alfalfa and sagebrush rangeland. Data required for the model consists of air temperature and humidity, windspeed, surface roughness, and an estimate of the effective resistance of the surface.

WORK PLAN FOR FY 1974

This investigation will be completed with the publication of the two manuscripts listed as Manuscripts in Progress.

REPORTS AND PUBLICATIONS

Belt, G. H. Spring evapotranspiration from low sagebrush range in southern Idaho. Technical completion report, Water Resource Institute, University of Idaho, Moscow, 40 pp., 1970.

Belt, G. H. Evapotranspiration from rangeland. Paper presented N.W. Science Assn. meeting, 1970.

Dirmhirn, I. and G. H. Belt. Variation of albedo of selected sagebrush range in the intermountain region. Agric. Meteorol., 9:51-61, 1971.

Hamon, W. R. and G. H. Belt. Hydrologic quantification of vegetation in western rangelands. Third Internl. Seminar for hydrology professors, Purdue University (seminar presentation), 1971.

<u>Manuscripts in Progress:</u>

Belt, G. H. Evapotranspiration models applied to semi-arid rangeland. To be submitted to Agric. Meteor., 1973.

Hamon, W. R. and G. H. Belt. Bulk energy balance-resistance evapotranspiration models. Paper to be presented at American Geophysical Union meeting, April 1973.

WATER QUALITY

Title: Water quality characteristics of the hydrologic flow regime of the Reynolds Creek Experimental Watershed

Personnel Involved:

G. R. Stephenson, Geologist	Responsible for coordinating activities with cooperators. Designs collection network and responsible for collection and analysis of water samples.
J. F. Zuzel, Hydr. Tech.	Responsible for collection of aquatic samples and statistical analysis of data.

Date of Initiation: October 1972

Expected Termination Date: Field Work - December 1974
Laboratory - February 1974
Interpretation and Summary - June 1975

INTRODUCTION

In recent years, because of the increased concern for the quality of our environment, many agricultural practices have come under close scrutiny as potential sources of air and water pollution.

Several agricultural practices are known to have contributed to pollution of surface and ground-water resources. Feedlot operations under certain conditions do contribute to increasing nitrate content of adjacent surface and ground water. Heavy grazing on open range compacts the soil and reduces infiltration, under certain conditions, and seriously reduces the vegetative cover, increasing runoff. Increased turbidity and sediment and nutrient production to the streams are often the result. Irrigation usually contributes heavily to total salt and nitrate-nitrogen content downstream. However, not all agricultural operations are detrimental.

Information is needed on the water quality characteristics of rangeland watersheds under natural conditions and various practices of land management. The Reynolds Creek Experimental Watershed offers an excellent opportunity to study water quality characteristics related to several of the above-mentioned problems. No commercial fertilizers or pesticides have been used on the watershed. Herbicides were used infrequently for sagebrush control, but not since 1965.

With the present distribution of hydrologic networks throughout the watershed, sampling of both surface and subsurface flow for water quality analyses can easily be accomplished. The water quality constituents can be related to the hydrology of the system, particularly the properties of the water, the distribution, and the circulation.

The BLM has expressed need for more information on water quality changes influenced by various land management practices. As more rangeland is being used for recreation, this information becomes more important.

Objectives: To determine water quality characteristics of the hydrologic flow regime of Reynolds Creek Experimental Watershed as related to:

1. Concentrations of cattle on local areas of rangeland and quasi-feedlot conditions,
2. Irrigation return flow, and
3. Natural soil and geologic conditions.

PROGRESS

Water samples were collected from 8 channel sites at bimonthly intervals starting in October 1972. These sites were established to give maximum variations in elevation, channel flow, soil and rock type characteristics, and land use. Sampling was started at the beginning of the water year (October).

Aquatic samples were taken concurrently with chemical sampling to determine composition and density of insect and other invertebrate fauna and algal species throughout the channel system. Composition and density counts were made in the laboratory following each sampling. Only preliminary statistical analyses have been prepared to date.

SIGNIFICANT FINDINGS

Analysis of the data from the first two samplings show that nitrate-N, except for a source area spring at 6,800 feet MSL, was present in amounts less than 0.7 mg/l throughout the channel system. Nitrate-N at the spring site ranged between 1.64 and 2.52 mg/l. The reason for this higher nigrate-N concentrate was probably related to soil and rock type characteristics above the spring.

Total phosphorous appears to be related to sediment concentration. The concentration of phosphorous-P increased downstream until the sediment pond at Tollgate Weir was reached. From limited samples, it appears that phosphorous-P concentrations were reduced considerably by this small sediment basin. Silica concentrations increased from an average of 9.4 mg/l at 6,800 feet elevation to 30.7 mg/l at the outlet of the watershed, 3,600 feet elevation. Fecal and total coliform counts showed the influence of concentrations of cattle, of soil bacteria, and, possibly, of sewage systems near the stream. The highest fecal coliform count of 325 counts/100 ml and a total coliform count of 6,000/100 occurred during the October sampling at a site where concentrations of cattle were in close proximity to the channel. Statistical analyses, using a between-site correlation model, indicated that some chemical constituents are related to elevation and drainage area parameters. These relationships appear to be logarithmic.

WORK PLAN FOR FY 1974

Eight sampling sites will be used along the channel system, ranging in elevation from 3,500 to over 6,000 MSL. These sites are located at weirs, springs, and tributary confluences where flow rates can be accurately measured. Several wells will be sampled in areas where cattle are confined in quasi-feedlot conditions. Sampling frequency will be semimonthly until irrigation starts in April. During the irrigation season, April through October, biweekly samples will be obtained while water quality parameters related to irrigation are studied. Standard laboratory procedures will be used in chemical analyses, including heavy metals. Aquatic sampling and analysis are scheduled concurrently with the chemical sampling and analyses. Statistical analyses will be performed as follows:

1. Between-site and within-site variables will be tested for significant relationships using correlation models.

2. Relationships occurring among within-site variables will be determined and the components will be tested for time variant behavior.

3. Relationships between significantly correlated variables will be determined using appropriate regression models.

The statistical analyses will be performed as quickly as possible following each sampling.

REPORTS AND PUBLICATIONS

None.

RUNOFF AND SEDIMENT

Title: Sediment yield from rangeland watersheds

Personnel Involved:

C. W. Johnson, Supvy. Hydr. Engr.	Plan programs and procedures; design and construct facilities for sediment studies; perform analyses and summarize results.
G. R. Stephenson, Geologist	Determine geologic and geomorphic parameters related to sediment yield.
R. L. Engleman, Hydr. Tech.	Perform data compilation and assist in analyses.

Date of Initiation: September 1, 1969

Expected Termination Date: December 1974

INTRODUCTION

Information on sediment yield is almost entirely lacking for millions of acres of predominantly sagebrush rangeland under Government land management and private ownership in the northwestern United States. There is a growing concern for soil losses from intensively grazed rangelands, sediment damage to reservoirs, and erosion of stream channels.

Most rangeland watersheds in the Intermountain Northwest have large areas of relatively steep hillslope topography, and these areas need to be delineated for treatment to reduce erosion. Also, sediment yield information is needed for evaluating the benefits of watershed management and land treatment programs of the Bureau of Land Management and Soil Conservation Service.

Range sites found in the Reynolds Creek Experimental Watershed represent a large percentage of the rangeland in the Northwest, and studies of sediment yield are essential for the development of sound management practices and in planning appropriate multiple use of these lands. Good land management decisions require information on how vegetative changes, fencing, and land use alter the sediment yield potential of rangeland watersheds. The sources of these sediments need to be determined so that research data can be used to predict sediment yield for ungaged areas in terms of available information on soils, climate, physiography, and use. Research is also needed to adapt the universal erosion equation to rangelands.

Objectives:

1. To determine the relationships between sediment yield and variables describing hydraulic and hydrologic factors, and site and watershed characteristics that influence sediment yield.

2. To formulate a sediment yield prediction procedure for rangeland watersheds in the Northwest.

Suspended and bedload sediment yields from plots, channels, and watersheds are measured by use of pumping sediment samplers, splitting devices, catchments, and hand sampling. Plots, microwatersheds, and watersheds are located on various soil types in different precipitation zones. A wide range of slope length, slope area, aspect, and relief ratio is represented. Rainfall intensity and duration data are available from a network of precipitation gages, and snow data are available from snow courses, snow pillow sites, and other snow-measuring sites. Also, data on cover, topography, and soil factors, which influence erosion and sedimentation, are available through other investigations at the Northwest Watershed Research Center.

PROGRESS

Construction and instrumentation of runoff-sediment plots were completed on three study areas in 1972 to complement existing facilities. The plots and small watersheds are designed to provide data from a variety of rangeland sites as flood and sediment-producing events occur. Field data are needed to evaluate the complex interaction of frozen soil, cover, snow accumulation, snowmelt, temperature, wind, and precipitation for actual storm and flood events.

As a result of near-record snow accumulation during the 1971-72 water year, runoff at most weirs was generally greater than 150 percent of the 10-year average.

Four significant storm runoff events occurred during the period December-March 1972. The weather, soil, and cover conditions were similar to those of major flood-producing events observed during the past 10 years. As usual, in early winter the soil froze to depths of 6 inches or more, and snow accumulated on the ground; then the strong warm wind from the southwest brought rain and snow. The storms produced a different runoff response at each watershed site, see Table 1. Consequently, erosion and sediment measurements showed extreme variability, see Figure 1.

Precipitation amounts for each of the four storm periods varied from about 1/2 inch at the lower elevations to about 3 inches at the higher elevations, except on January 18 when the greatest precipitation was only about 2 inches. Precipitation on January 18 was mostly rain below 5,000 feet and snow at higher elevations. However, during the other three storms, rain and runoff generally occurred at higher elevations.

The percentage of total water-year runoff that occurs during each month is shown in Figure 2, based on a 10-year period of record. The Reynolds

Mountain Weir provides runoff measurement from 100 acres, Tollgage Weir from 13,453 acres, and the Outlet Weir from 57,700 acres. Weir elevations are 6,600 feet, 4,600 feet, and 3,600 feet respectively.

Analyses of suspended-sediment data collected during 1972 were not completed in time for this report. However, preliminary results show sediment yields only slightly above normal. Winter storms, as usual, caused the greatest sediment movement.

SIGNIFICANT FINDINGS

Data from four midwinter storms in 1972 show that watershed areas contributing to runoff and sedimentation are extremely variable, depending upon the influence of frozen soil, snowmelt, precipitation (rain or snow), wind, temperature, topography, and vegetation. The extensive hydrologic network on the Reynolds Creek Watershed provides needed data for studies of rangeland runoff and sedimentation.

Measurements of suspended sediment from small watersheds (2-5 acres) during peak winter runoff showed a range of sediment concentrations from about 1,000-84,000 p.p.m., with the greatest amount from a small, poorly vegetated, steep, hillside watershed.

WORK PLAN FOR FY 1974

Collection of data from plots, microwatersheds, and watersheds will continue with emphasis on sampling during major storm events when the greatest sediment movement occurs.

Runoff and sediment data from all Reynolds Creek Watershed stations will be processed for use in watershed and sediment models.

Erosion on steep-sloped, bare hillsides will be studied by use of plots and tracers.

REPORTS AND PUBLICATIONS

Overton, D. E., H. E. Judd, and C. W. Johnson. Optimizing resistance coefficients for large bed element streams. Report PRWG 59a-1, Utah State Univ., Logan, June 1972.

TABLE 1.--Data for Major Runoff Events in 1972

Hydrologic Variables	Locations	Measured Values for 1972 Storm Events			
		Jan. 16-18	Jan. 20-22	Feb. 23-28	March 1-3
Precipitation (inches)	R.G. No. 076X59	rain 0.55	rain 0.92	rain 0.50	rain 0.71
	R.G. No. 127X07	rain 0.39	rain 1.02	rain 0.71	rain 0.81
	R.G. No. 176X07	snow 2.23	snow 4.44	mixed 3.82	snow 2.90
Frost Depth (inches)	Sta. 076059	4	0	2/ 4	0
	Sta. 127007	4	1/ 4	2	--
	Sta. 176014	0	0	0	0
Snow-on-Ground (inches)	Sta. 076059	2	0	0	1
	Sta. 127007	5	2	2	--
	Sta. 176007	60	76	--	87
Wind (Sta. 176014)	Direction	SSW	SW	SW	SW
	Vel. (mph)	20-35	20-35	20-30	20-35
Temperature (°F)	Sta. 076059	42-47	47-32	45-54	30-50
	Sta. 127007	38	38-30	40-46	30-40
	Sta. 176014	24-32	--	--	15-35
Runoff (inches)	Micro 057096	0.45	0	0	0
	Micro 098097	.53	.01	0	0
	Sta. 036068	.11	.17	.26	.34
	Sta. 043004	.27	.45	.45	.85
	Sta. 046017	.18	.22	.18	.45
	Sta. 048077	0	0	0	0
	Sta. 116083	.08	.30	.50	.50
	Sta. 117066	.08	.32	.15	.11
	Sta. 138034	0	0	.10	.11
	Sta. 176076	0	0	.12	.10

1/ Thawing on top

2/ Top 3" thawed

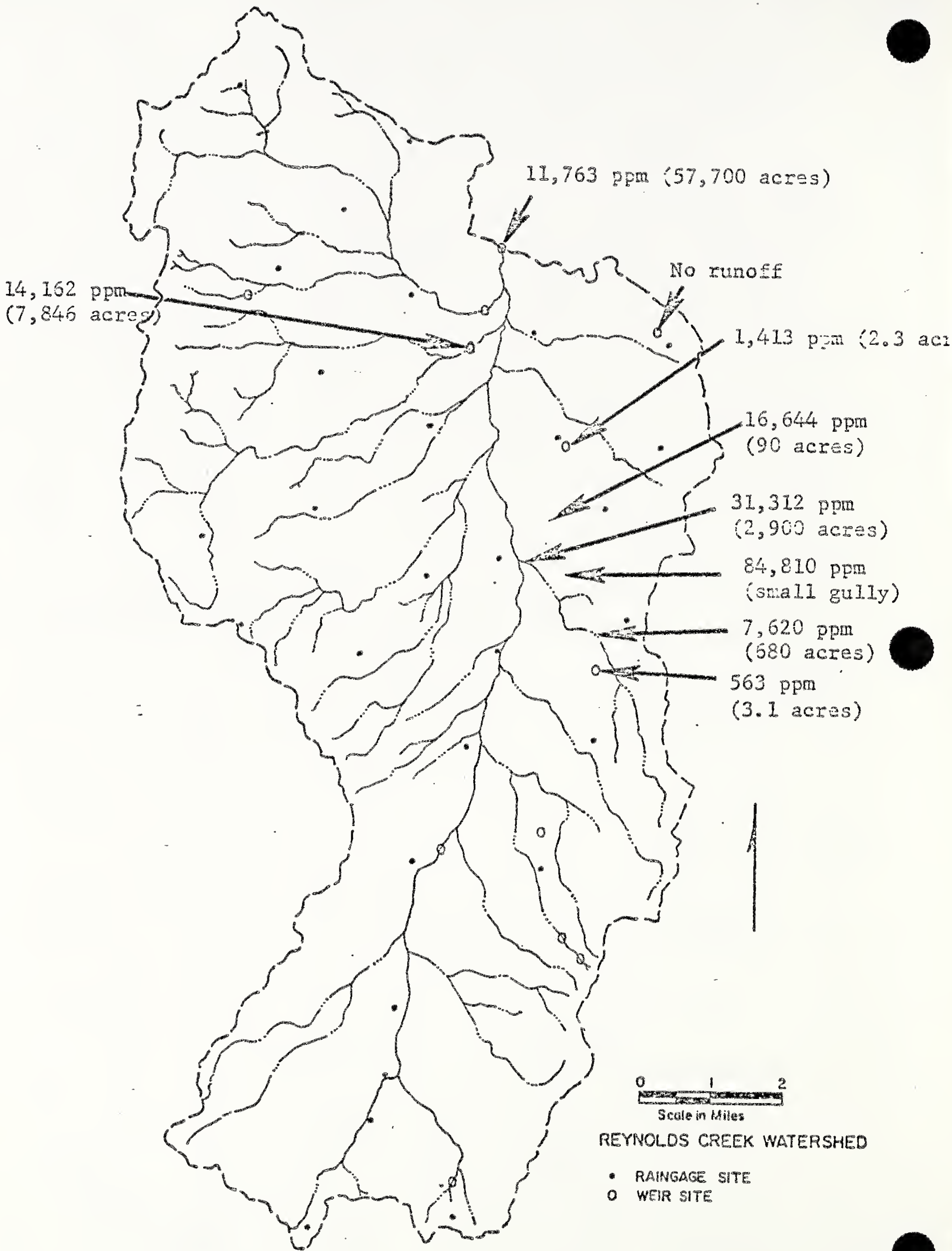

Figure 1. Maximum measured suspended sediment concentrations at selected stations, Reynolds Creek Watershed, January 18, 1972.

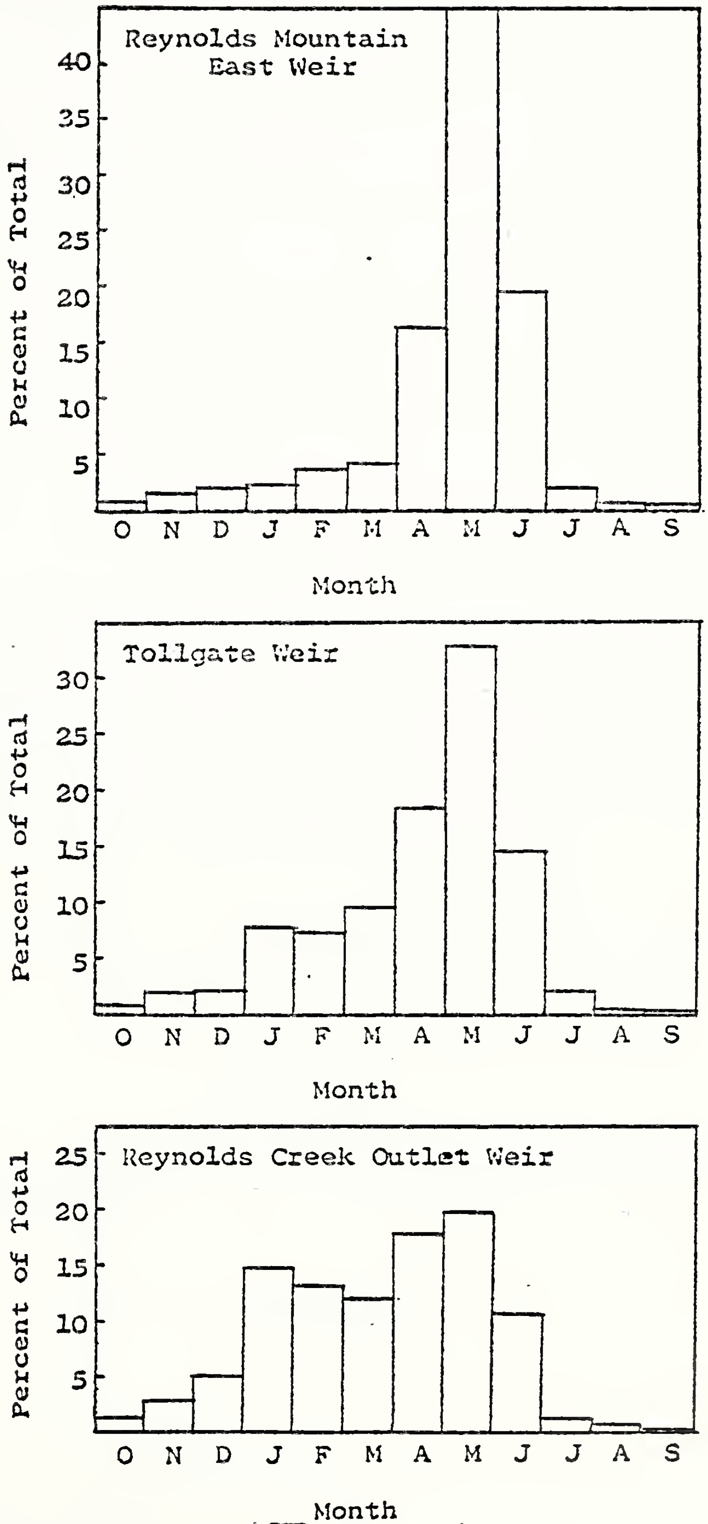

Figure 2. Distribution of runoff at selected stations.

FRAIL LAND STUDIES

Title: Hydrology of frail land watersheds

Personnel Involved:

C. W. Johnson, Supvy. Hydr. Engr.	Perform water balance and any other analysis needed.
W. J. Rawls, Hydrologist	Perform water balance and other analysis needed.

Date of Initiation: October 1968

Expected Termination Date: Field Work - October 1973

Interpretation and Summary - July 1974

INTRODUCTION

Proper management of watersheds for multiple use and protection requires a complete knowledge of the water balance with independent assessments of the water balance components. In order to determine the individual components for frail lands, a study of the hydrology of two watersheds, Rabbit Creek and Little Rabbit Creek, adjoining the Reynolds Creek Experimental Watershed, was initiated in 1968. A complete description of the watersheds and instrumentation was included in the 1968-69 water-year report.

Objective:

To determine the water balance of two frail land watersheds in the Northwest.

PROGRESS

Operation of five dual raingage installations, two runoff stations, and 10 soil moisture measuring sites were continued in 1972 and 1973. The data are being processed and checked.

SIGNIFICANT FINDINGS

None.

WORK PLAN FOR FY 1974

A detailed water balance covering a 5-year period from 1968 to 1973 will be submitted in 1974.

REPORTS AND PUBLICATIONS

. Northwest Watershed Research Center. Hydrology of Rabbit Creek watersheds, Owyhee County, Idaho, 1969-70 water year. December 1971. (Report to BLM-USDI, Boise District Office)

APPENDIX A

COMPUTING ACTUAL PRECIPITATION[1]

W. Russell Hamon[2]

SUMMARY

An analytical model for computing actual precipitation from unshielded and shielded gauge data, independent of windspeed and type of precipitation, was derived by use of exponential wind functions to relate the ratios of catch by unshielded and shielded gauges to actual precipitation. The single calibration coefficient in the model has been experimentally verified in the field. The ratios of unshielded and shielded gauge catch to actual precipitation were evaluated, by use of computed actual precipitation obtained by applying the model, as a function of windspeed and temperature.

RESUME

Par une méthode analytique on a établi un projet pour estimer la précipitation effective à l'aide d'observations basées sur une jauge protégée et une jauge non-protégée contre les rayons du soleil et indépendamment de la vélocité du vent et du type de précipitation. On s'est servi des fonctions exponentielles du vent pour mettre en rapport la précipitation effective avec l'accumulation dans les deux jauges. Le coefficient à appliquer alors à un mesurement unique du modèle a prouvé la validité de ce qu'on avait gagné d'une façon expérimentale. On a mesuré, comparé et évalué ~~le~~ rapport entre l'accumulation d'eau dans les deux jauges avec la précipitation effective en se servant des évaluations de la précipitation obtenues par l'emploi du modèle, en y apportant les données de la vélocité du vent et de la température.

[1]Contribution from the Soil and Water Conservation Research Division, Agricultural Research Service, USDA; Idaho Agricultural Experiment Station cooperating.

[2]Research Hydraulic Engineer, Northwest Watershed Research Center, Soil and Water Conservation Research Division, Agricultural Research Service, USDA, Boise, Idaho.

INTRODUCTION

Precipitation is the prime element in the hydrologic cycle, and there is conclusive evidence from many studies over the past 100 years that errors in present-day methods of measurement are large enough to seriously affect water resource studies and water supply forecasts. The problem of areal precipitation variability cannot be adequately handled until point measurements are made with acceptable accuracy.

No hydrological or meteorological instrument has been accorded so much attention for such a long period of time as the raingauge. The history of its development and use since the fourth century B. C. has been recorded by Biswas /1/. An annotated bibliography of 1,079 references and a discussion on the methods and instruments used for measuring precipitation from early history to 1953 has been prepared by Kurtyka /2/. Recently, Israelsen extended the work by reviewing 164 additional references /3/. An updated version of the Kurtyka report is being prepared by Rodda[3] under the auspices of the World Meteorological Organization and will contain about 1,600 references.

The earliest type of gauge was the "bucket" or "standpipe" design, and the ordinary gauges in use today have the same type of precipitation collectors. The physical existence of the gauge in the presence of wind hinders its operation since the resulting disturbance in the airflow influences the precipitation pattern in the vicinity of the gauge. As shown by Warnick /4/, the gauge causes an updraft over the horizontal orifice of the collector along with increased windspeed--both effects tending to prevent precipitation particles from entering the gauge.

The actual catch of an ordinary precipitation gauge is principally a function of the true precipitation, physical configuration of the gauge, fall velocity of the precipitation particles, windspeed at the gauge orifice, and meteorological conditions that influence evaporation, riming, and the development of "snow crowns."

Kurtyka /2/ found that individually the effects of errors in gauge catch are nearly always in a negative direction. The error due to wind was as much as 80 percent for snow, while all other errors combined were in the order of 2-3 percent when the gauge was not subject to splash from raindrops.

Several gauge shields have been devised in an effort to reduce the influence of wind on gauge catch. In 1878, Nipher /5/ developed an inverted cone shield with the small end fitting tight against the collector. This shield was used with modification until 1937 when Alter /6/ introduced a shield with flexible swinging baffles which would not collect snow.

Investigations by Tret'yakov /7/ led to the development of a precipitation gauge with a semirigid shield that was incorporated in the entire network of the U.S.S.R. in 1952. Studies by Bogdanova /8/ showed that the Tret'yakov gauge was inadequate, particularly for snow. The same conclusion, as verified by data obtained by Warnick /4/, is applicable to the Nipher and Alter shields.

For rainfall, pit or ground gauges adequately protected from splash are considered to reliably measure the ground-true precipitation. Studies of the pit gauge performance in England by Rodda /9/ revealed deficits of 3-7 percent for the standard British gauge (Met. Office MK 2 gauge). The Commission for Instruments and Methods of Observations of the

[3]Personal communication from Dr. John C. Rodda, Institute of Hydrology, Wallingford, England.

World Meteorological Organization is coordinating studies in more than 30 countries on the deficiencies of rainfall catch by national official gauges in relation to pit gauge measurements.

Bogdanova /8/ obtained considerable scatter in the relationship between windspeed and gauge catch deficiencies for both rain and snow, even when observations were grouped for particular windspeeds. A procedure for correcting these gauge catch deficiencies, using the Tret'yakov gauge and adjusting the catch for wind at intervals of temperature, has been reported by Struzer et al /10/. This procedure has been used to adjust precipitation estimates for the U.S.S.R. as reported by Struzer et al /11/. These total corrections to annual precipitation range from about 10 percent in the most southern regions to more than 50 percent in the northern regions.

ANALYTICAL MODEL

In searching for an analytical model, a basic consideration was adopted: a physical object such as a precipitation gauge, regardless of its configuration, will influence the windstream and affect the trajectories of the precipitation particles, thereby altering the vertical flux of precipitation in the vicinity of the gauge. This led to the formulation of the hypothesis that since the wind effect is reduced by the use of a shield, the catches obtained by a shielded and an unshielded gauge could be used to compute actual precipitation if a suitable analytical expression could be found for the influence of wind and the fall velocity of precipitation on the gauge performance. Struzer /12/ used similar reasoning to obtain correction coefficients by using the catches of a shielded and an unshielded gauge along with temperature.

Data from studies reported by Warnick /4/ and Bogdanova /8/ indicate an exponential relationship between the ratio of gauge catch and true catch for both shielded and unshielded gauges as a function of wind as shown in Figure 1. By introducing a temperature index, T_i, to adjust for the influence of different fall velocities of precipitation particles and considering S the shielded gauge catch, U the unshielded gauge catch, A the actual precipitation, and W the windspeed at the gauge orifice, the analytical model was developed as follows with W represented as a function of T_i:

$$\frac{S}{A} = e^{-aW(T_i)} \tag{1}$$

$$\frac{U}{A} = e^{-bW(T_i)} \tag{2}$$

The term A is eliminated to obtain

$$\frac{U}{S} = e^{-(b-a)\,W\,(T_i)} \tag{3}$$

Equations 2 and 3 are combined to obtain

$$\log_e\left(\frac{U}{A}\right) = B \log_e \frac{U}{S} \tag{4}$$

in which

$$B = \frac{b}{b-a} \tag{5}$$

where B is a calibration coefficient and a and b are coefficients.

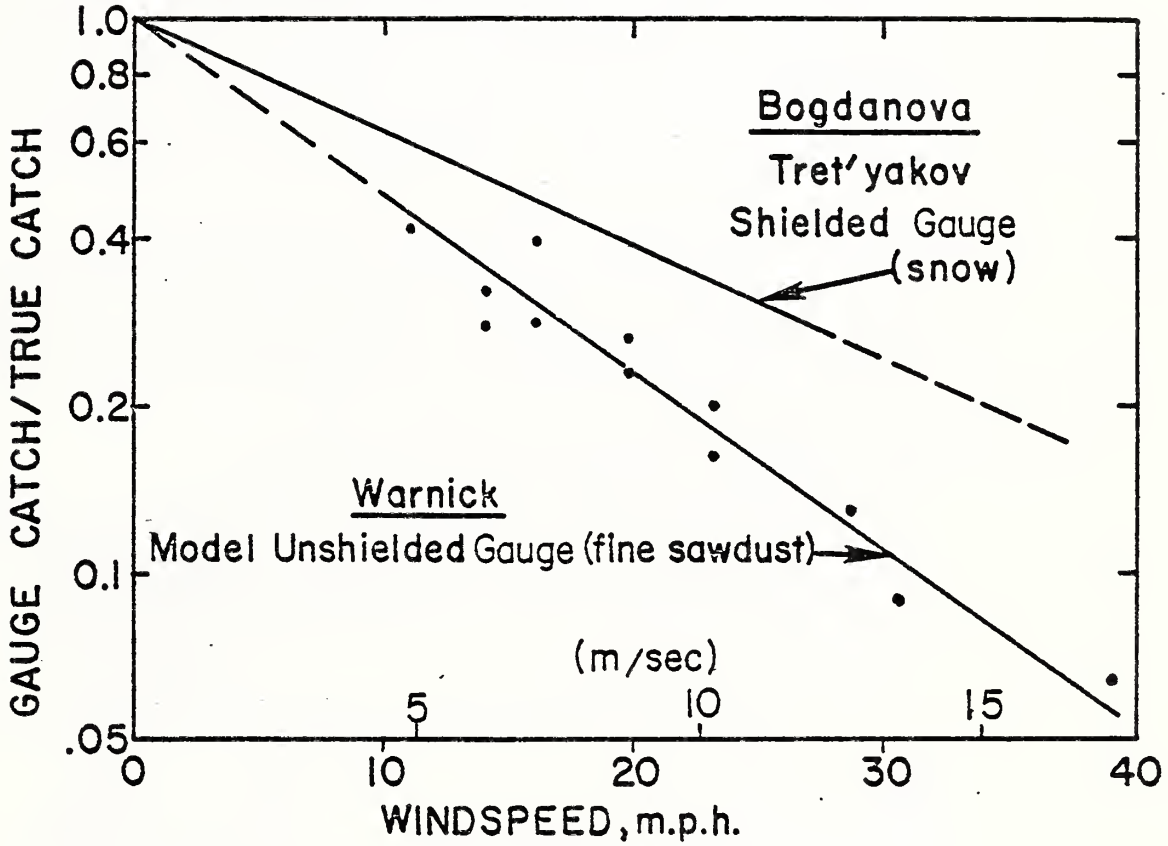

Figure 1. Ratio of gauge catch to true catch for an unshielded and a shielded gauge versus windspeed.

As indicated in Equation 4, the actual precipitation is obtained by using data from the shielded and unshielded gauges and an appropriate value of the calibration coefficient. The fall velocity (form of precipitation) and wind terms are eliminated since the two gauges are exposed to the same environment.

EXPERIMENTAL VERIFICATION OF MODEL

Instrumentation and Data

Instrumentation was developed and installed in 1967-68 to obtain field data for verifying the model. Standard recording precipitation gauges of the National Weather Service were used. The shield used was constructed similarly to a modified Alter shield, diameter of 46 inches (1.17 meters), but with each baffle individually constrained at an angle of 30 degrees from the vertical to maintain a constant airfoil. Integrating anemometers, a snow pillow and a hygrothermograph completed the instrumentation at two study sites located at 6800 feet or 2073 meters (m.s.l.) in southwestern Idaho (Lat. 42° 15' N., Long. 116° 45' W.).

Temperature, wind profile data, and precipitation data from a profile of unshielded gauges and from shielded gauges with orifices at 5 and 10 feet (1.52 and 3.05 meters) were obtained at the exposed precipitation gauge evaluation site (176x14), Figure 2. Snow-water content from a 12-foot (3.66-meter) diameter butyl rubber snow pillow and precipitation data from an unshielded and a shielded precipitation gauge were obtained at the protected site (176x07), Figure 3. The unshielded and shielded gauges with orifices at 10 feet (3.05 meters) were used as model gauges.

Relationship of Unshielded to Shielded Gauge Catch

Storm precipitation obtained from the dual gauges (shielded and unshielded gauges with orifices at 10 feet or 3.05 meters), average windspeed at 10 feet or 3.05 meters, and average temperature at the two sites were used to obtain the curves in Figure 4, according to Equation 3. The ratio U/S is applicable to any orifice height if the windspeed is measured at that same height. The values of temperature, T_i, used to separate the data and the pertinent evaluation statistics, are listed in Table 1.

TABLE 1.--Evaluation statistics of the logarithum of the ratio of unshielded to shielded gauge catch as a function of windspeed and temperature, and of Equation 3.

Temperature (T_i)	Cases No.	Intercept[3]	r[4]	Means			Equation 3	
				U/S	Wind m.p.h.	Wind m/sec.	S_{yx}[5]	(b-a)
T > 1.67°C.	35[1]	0.99	-0.74	0.92	9.4	4.2	0.03	0.0086
1.67° ≥ T > 0°C.	21[2]	1.02	-0.75	0.79	14.1	6.3	0.06	0.0173
0° ≥ T > -5°C.	42	0.93	-0.73	0.69	13.2	5.9	0.10	0.0310
-5° ≥ T > -10°C.	20	0.80	-0.75	0.57	11.6	5.2	0.11	0.0523

[1]All rain cases.
[2]Mixed rain and snow.
[3]Obtained from least squares fit of data.
[4]Correlation coefficient. Positive values from correlation of predicted (Equation 3) and observed U/S. All values significant at 1 percent level.
[5]Standard error of estimate.

The statistics in Table 1 reveal that Equation 3 is satisfied and that the specifying equations (Equations 1 and 2) are not rejected.

Figure 2. Precipitation gage evaluation site.

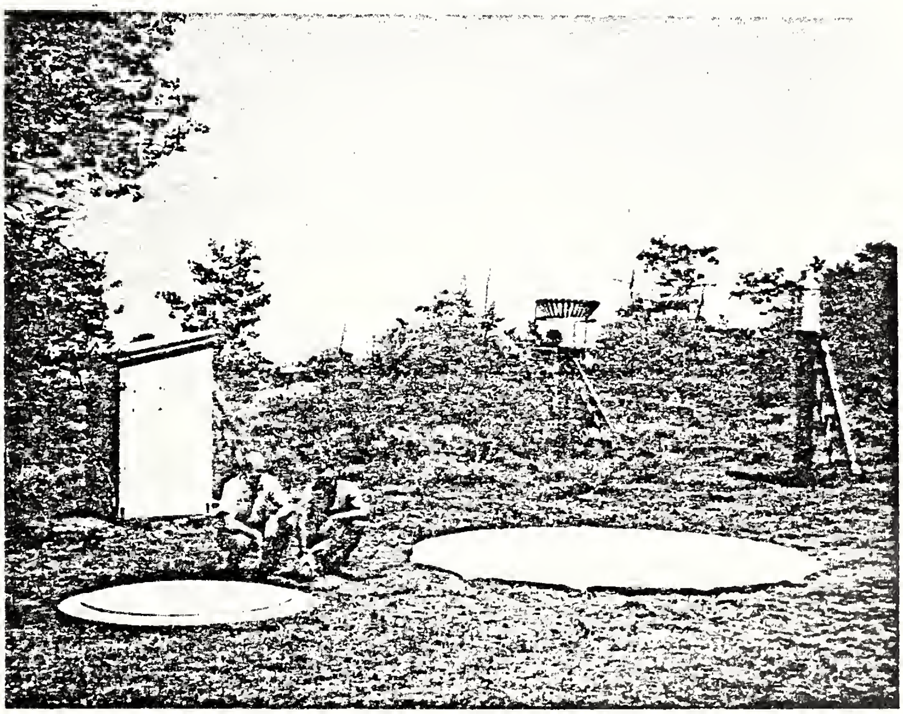

Figure 3. Snow pillow site.

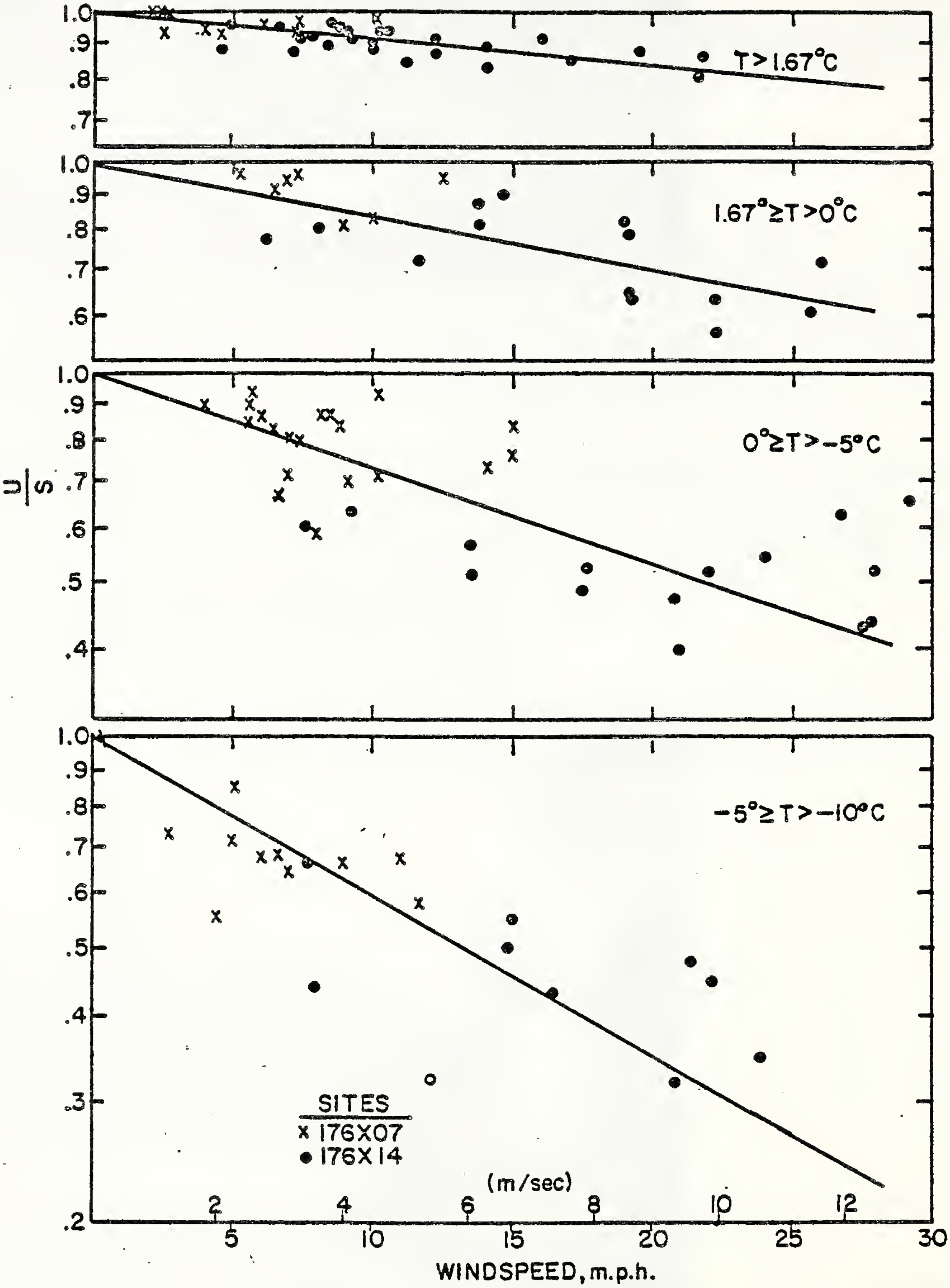

Figure 4. Ratio of unshielded to shielded gauge catch as a function of windspeed and temperature.

Evaluation of Calibration Coefficient

The analytical model for calculating actual precipitation represented by Equation 4 contains a calibration coefficient, B, which must be experimentally determined by direct or indirect measurement of actual precipitation. As pointed out earlier, a pit gauge may be used as a "standard" device for accurately measuring rain. Because there is no known direct method for measuring snowfall, data from gauges or snow-water equivalent measurements at wind-protected sites are normally used. Snow pillow data and profile techniques were used in this study to assess actual precipitation.

Snow Pillow Data

Data from the 12-foot (3.66-meter) diameter snow pillow for actual storm precipitation and data from the adjacent shielded and unshielded precipitation gauges were used to evaluate the calibration coefficient in Equation 4. Storm data for the winters of 1967-68 1968-69, and 1969-70 were used, with elimination of data for certain conditions. Data were considered unacceptable when the ratio U_{10}/S_{10} was less than 0.55. Windspeeds corresponding to this ratio are obtained from Figure 4 and were considered to produce excessive movement of snow at the snow pillow site as indicated by recorder traces. Only data for December, January, and February were used, since temperature effects caused erratic behavior in the snow pillow in March. All data influenced by melt conditions were discarded.

The calibration coefficient had a value of 1.70 (B = 1.70) when obtained for the means of the logarithms (Figure 5). The two circled points in the figure were ignored since there appeared to be riming conditions with temperatures around 0°C. The line shown was drawn through the mean and the origin. Since the same quantity, U_{10}, occurs in the ordinate and abscissa of Figure 5, as required by Equation 4, an evaluation of the accuracy of the relationship was made by comparing the predicted values with the observed values (Figure 6).

Profile Techniques

Profiles of precipitation gauge catch (obtained by unshielded gauges with orifices at 3.5, 5, 7, 10, and 14 feet or 1.07, 1.52, 2.13, 3.05, and 4.27 meters) and of wind (measured at 5, 7, and 10 feet or 1.52, 2.13, and 3.05 meters) were used to estimate precipitation catch at the level of the theoretical zero windspeed. The wind profile for neutral atmospheric stability is given by

$$\log_e \left[\frac{Z - D}{Z_o}\right] = K_1 W \tag{6}$$

where Z is height above the ground surface, D is displacement height resulting from a vegetation or snow cover, Z_o is the roughness parameter or height above D where the windspeed extrapolates to zero, and K_1 is a constant. By combining Equations 2 and 6, the precipitation gauge catch profile takes the form

$$\log_e \left[Z - D\right] = -K_2 \log_e U - K_3 \tag{7}$$

The terms K_2 and K_3 are curve-fitting constants since, for the individual profile of unshielded gauge catch, the quantities Z_o and A are constants and the temperature index is the same for all gauges.

Estimates of actual precipitation, or the values of U at heights Z_o, were obtained from Equation 7 by substituting the appropriate values of Z_o for (Z-D). The values of Z_o were obtained by analysis of the wind profiles by using data from three anemometers (Figure 2). A total of nine profiles was used to calculate the vertical flux of precipitation

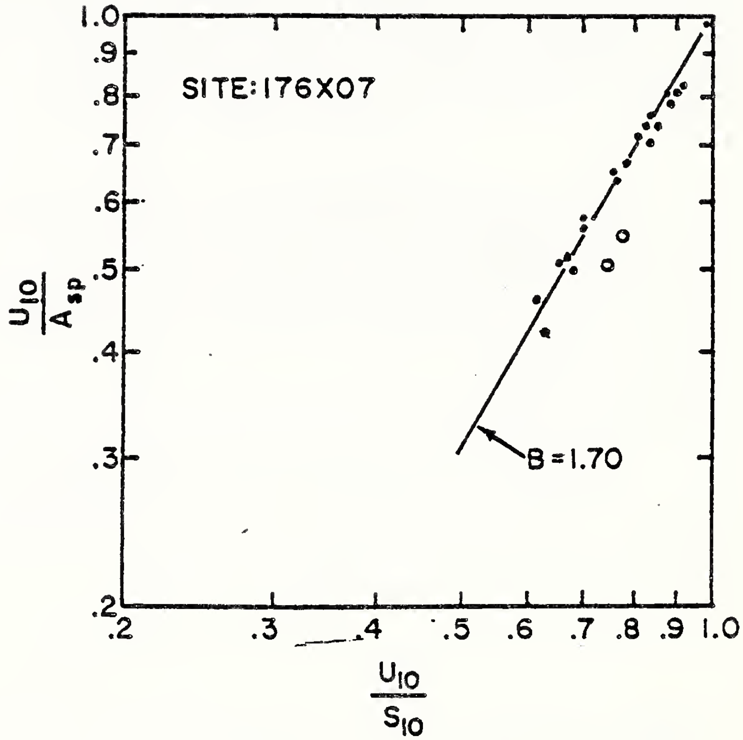

Figure 5. Ratio of unshielded gauge catch to actual precipitation (snow pillow data, Asp) versus ratio of unshielded to shielded gauge catch.

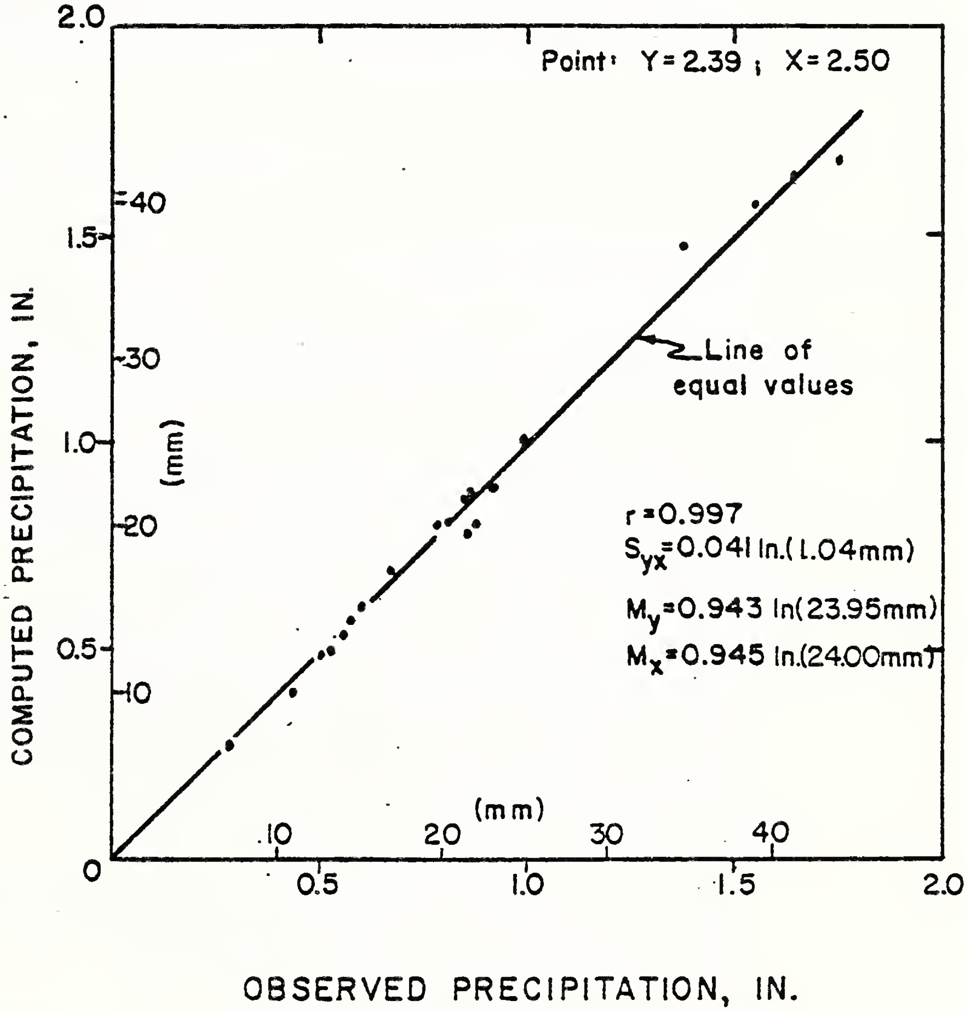

Figure 6. Computed precipitation as obtained from Equation 4 with B = 1.70 versus observed precipitation as measured by snow pillow.

by use of Equation 7. In only three of the nine cases were temperatures low enough to indicate snowfall. The available cases were limited because of unavailable wind data and the restrictions that the correlation be greater than that expected at the 5 percent probability level for the wind profile and 10 percent for the precipitation profile. The ratios obtained by the wind profile method for evaluation of the calibration coefficient equations are plotted in Figure 7.

Since precipitation data were obtained from both shielded and unshielded gauges at the 5- and 10-foot (1.52- and 3.05-meter) heights, a double profile technique could be used. The flux of precipitation is the same at both heights; therefore, Equation 4 can be solved simultaneously for the two profiles to obtain

$$\log_e \left[\frac{U_{10}}{U_5} \right] = B \log_e \left[\frac{U_{10}/S_{10}}{U_5/S_5} \right] \tag{8}$$

where U_{10} and S_{10} represent the 10-foot (3.05-meter) gauges, and U_5 and S_5 represent the 5-foot (1.52-meter) gauges.

A total of 17 rainstorms and 11 snowstorms were analyzed by using Equation 8. The selection of storms was predicated on a reasonable and consistent precipitation profile as obtained by the unshielded profile gauges.

The calibration coefficient for the rainstorms was 1.68 (B = 1.68) and for the snowstorms the coefficient was 1.66 (B = 1.66). Values of the ratios as defined in Equation 8 for the double profile results were plotted, in addition to the wind profile cases in Figure 7. The combined data results in a calibration coefficient of 1.73 (B = 1.73).

<u>Significance of the Calibration Coefficient</u>

Snow pillow data, representing actual precipitation, and precipitation data as obtained by the dual gauges (shielded and unshielded) were used to verify the analytical model as represented by Equation 4. In further substantiation of the model, Equation 3 was found to be applicable as demonstrated in Figure 4 and verified by the statistics as presented in Table 1. The calibration coefficient of 1.70 (B = 1.70), obtained by use of the snow pillow data was verified by the independent analysis of profile data which gave a coefficient of 1.73.

The profile precipitation data were used to eliminate those storms that caused riming or "snow crowning" of the orifices. This resulted in the determination of a coefficient that most nearly represents the true effect of wind. Data from storms in which excessive snow was retained on the orifices, particularily the shielded gauge orifice because of reduced windspeed, produced larger coefficients.

The calibration coefficient is apparently independent of windspeed and forms of precipitation. The dual gauges, therefore, can be used to obtain measurements that may be used to calculate actual precipitation, without wind and temperature data, when windspeeds are great enough to clean the orifice of snow and when excessive riming does not occur.

RELATIONSHIP OF UNSHIELDED AND SHIELDED GAUGE CATCH TO ACTUAL PRECIPITATION

With a firm determination of the calibration coefficient, B = 1.70, and by use of Equation 5, it is possible to establish values of the coefficients in Equations 1 and 2

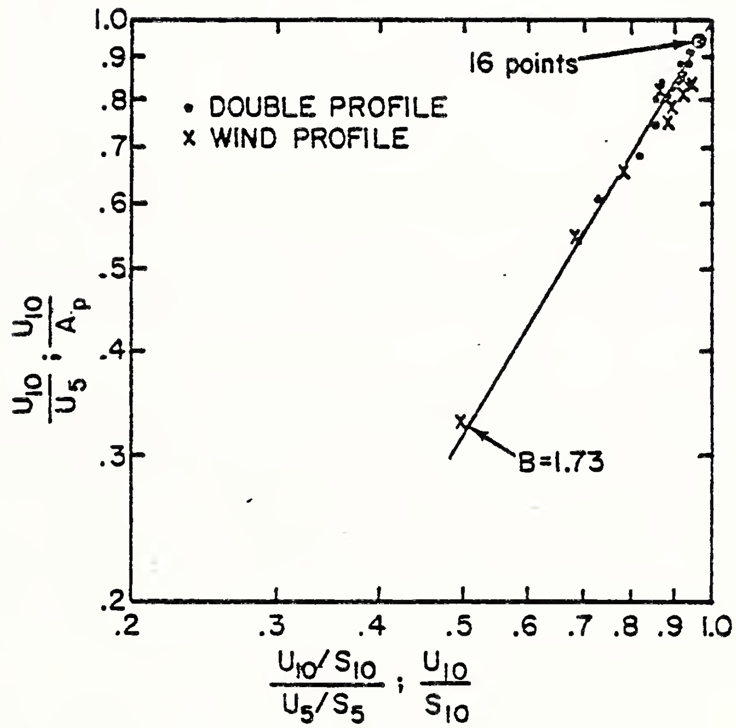

Figure 7. Relationship of ratios from Equations 4 and 8 where Ap represents precipitation at the zero wind plane.

since the value of (b-a) in Equation 3 has been obtained over a range of temperatures (Table 1). Applicable values of the coefficients required to obtain the ratios of unshielded gauge catch and shielded (rigid) gauge catch to actual precipitation as a function of wind and temperature are given in Table 2.

TABLE 2.—Coefficients for estimating actual precipitation from either unshielded or shielded (rigid) gauge catch by utilizing windspeed and temperature data.

Temperature range (T_i)	Coefficients for Equations 1 and 2	
	a	b
T > 1.67°C.	0.0060	0.0146
1.67° ≥ T > 0°C.	0.0121	0.0294
0° ≥ T > -5°C.	0.0217	0.0527
-5° ≥ T > -10°C.	0.0366	0.0889

DISCUSSION

As shown by a number of investigators, the principal error in measuring precipitation by a "bucket" type gauge is caused by wind. Attempts to design gauges to elimi[illegible] the wind influence have not been successful, since any physical object placed in an [illegible] stream will distort both the wind and precipitation fields in the vicinity of the gauge.

The separate and independent analyses used to verify experimentally the analytical model, Equation 4, demonstrated that the calibration coefficient remained reasonably constant for windspeeds up to 30 miles per hour and for both rain and snow. With this fact established, only data from a dual arrangement of an unshielded and a shielded (rigid) gauge are required to compute actual precipitation. The data indicate that storm precipitation can be calculated with an error of less than 10 percent for snow and 5 percent for rain for a windspeed up to 30 miles per hour. Gauges with adequately heated orifices could reduce the snow measurement error. The error, of course, will decrease with the accumulation of precipitation. Such delayed calculations are possible since the gauges integrate the totals used in calculating actual precipitation.

The analytical model was developed from exponential functions involving the ratios of unshielded and shielded gauge catch to actual precipitation in terms of windspeed and temperature. Verification of the model, with the establishment of a value for the calibration coefficient, made it possible to determine the coefficients in the exponential functions. Data from either the unshielded or the shielded (rigid) gauge can now be used with wind and temperature data to adjust the catches of the gauges into better estimates of actual precipitation. Such relationships can be obtained for other types of gauges by using consecutive data from these gauges and the gauges used in this study, along with windspeed and temperature data.

For satisfactory performance of dual gauge installations, the unshielded and shielded gauge orifices must be at the same height above the ground surface (no fixed height is required). The gauges should be situated so the airflow at the gauge orifices is not influenced by either gauge or other objects, and the exposure should be such that the airflow at the gauge orifices is essentially horizontal. The gauges should be located a[illegible] exposed sites, since capping by snow or the formation of snow crowns can seriously a[illegible]

the performance of unheated gauges.

Calculated precipitation, utilizing data for 1969-71 from dual gauges located at an elevation of 7,000 feet (2134 meters) in southwestern Idaho, resulted in significant departures from the unshielded and from the shielded gauge catches. For an annual calculated precipitation of about 50 inches (127 cm.), the deficiencies in catch amounted to 35 percent for the unshielded gauge and 20 percent for the shielded gauge.

CONCLUSIONS

The following conclusions are drawn from the study:

1. The analytical model developed for computing actual precipitation from unshielded and shielded (rigid) gauge data is essentially independent of windspeed and type or form of precipitation.

2. The single calibration coefficient in the model was experimentally determined to have a value of 1.70 for the type of gauge and the rigid shield used when the windspeed and snow were such that the gauge orifices remained unobstructed.

3. A profile technique, utilizing profile catches of unshielded gauges and wind-profile data, is a useful method for calculating the actual precipitation required to evaluate the calibration coefficient.

4. Functional relationships between the ratios of unshielded and shielded gauge catch to actual precipitation in terms of windspeed and temperature, with coefficients evaluated by use of the model, can be used to compute actual precipitation.

5. The error in precipitation data collected by the unshielded gauge at windspeeds of 10 miles per hour (4.5 meters per second) is about 15 percent for rain and 25-60 percent for snow and at windspeeds of 20 miles per hour (8.9 meters per second) the error is about 25 percent for rain and 45-80 percent for snow. For the shielded (rigid) gauge, these errors are reduced by about 50 percent for rain and by 35-50 percent for snow.

6. Storm precipitation can be computed from unshielded and shielded (rigid) gauge data with an error of less than 10 percent for snow in the absence of capping and 5 percent for rain for windspeeds up to 30 miles per hour (13.41 meters per second).

7. Orifices of the dual gauges must be at the same height above ground (no fixed height is required), and the gauges should be situated so the airstream is essentially horizontal and uninfluenced by obstructions.

8. The dual gauges perform best at exposed locations, since capping by snow and the formation of "snow crowns" can cause serious errors in catch. Heated gauges could possibly remedy this problem.

9. The analytical model, data from the dual gauges used in this study, and consecutive data from other gauges, along with windspeed and temperature data, can be used to develop predictive relationships for other gauges by establishing the ratio of gauge catch to actual precipitation as a function of windspeed and temperature.

ACKNOWLEDGMENTS

The author is grateful to Mr. David C. Robertson, Engineering Technician, for his significant contribution in instrumentation, data collection, and analysis and to Dr. Lloyd M

Cox, Hydrologist, for sharing data from snow experimental sites.

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APPENDIX B

INFILTRATION

Table of Contents

APPENDIX B

Soil profile descriptions were prepared by the area SCS soil scientist in accordance with USDA Handbook No. 18, Soil Survey Manual.[1/] Profile descriptions for each study area are presented in Tables B2, B4, and B6. The dry bulk densities were determined by core sampling methods[2/] and are presented in Tables B3, B5, and B7 for each study area. Cover was determined by using the point transect method, and these measurements are summarized in Table B1.

1/ U. S. Soil Survey Staff. Soil Survey Manual, U. S. Dept. of Agriculture Handbook, No. 18, pp. 503, 1962.

2/ Black, C. A., D. D. Evans, J. L. White, L. E. Ensminger, and F. E. Clark. Methods of Soil Analysis Part 1 Physical and Mineralogical Properties Including Statistics of Measurement and Sampling. Number 9 in series of Agronomy, Amer. Soc. of Agronomy, Inc. pp. 375-378, 1965.

Table B1.--Plot Cover Data

Plot Number	Vegetation (%)	Litter (%)	Rock Large(1"+) (%)	Rock Small(1/8"-1") (%)	Bare Ground (%)
68057396	40.17	29.09	0.00	1.34	29.36
68057196	14.57	2.24	0.28	12.32	70.59
68098Y97	35.55	38.67	1.17	0.00	24.61
68098Z97	39.26	10.40	5.37	10.07	34.90
68127D07	53.55	8.66	3.54	20.08	14.17
68127F07	42.66	13.30	9.97	28.25	5.82

Table B2.--Soil Profile Description for Flats

Location - Flats
Soil Name - Nannyton loam
Classification - Fine-loamy, mixed, mesic family of Typic Haplargids
Location - At rainfall similator test site #057496, Lakebed Flats
Natural Vegetation - Shadscale, big sagebrush, cheatgrass and peppergrass
Climate - Approx. 8" mean annual precipitation with dry summers; mesic temperature regime
Parent Material - Lacustrine and possibly some alluvial material
Physiography - Dissected old lake terrace
Relief - Undulating
Slope - 2 to 3 percent, northwest facing
Drainage - Well-drained
Ground Water - Deep, probably more than 20 feet
Elevation - About 4000 feet
Stoniness - None or slight
Erosion - Slight
Permeability - Moderate

Profile Description - (Colors are for dry soil unless noted otherwise.)

A21 -- 0-2" -- Pale brown (10YR 6/3) slightly gravelly sandy loam; dark grayish brown (10YR 4/2) moist; moderate, thin, platy, parting to weak fine granular structure; soft, very friable, nonsticky, nonplastic; common fine and few medium roots; many fine and medium vesicular pores; noncalcareous; clear smooth boundary.

A22 -- 2-5" -- Light gray (10YR 7/2) gritty loam; dark brown (10YR 4/3) moist; weak, thin, platy, parting to weak fine granular structure; soft, friable, nonsticky, slightly plastic; common fine and medium roots; many fine vesicular pores; noncalcareous; gradual smooth boundary.

A3 -- 5-8" -- Very pale brown (10YR 7/3); slightly gravelly loam with fine gravel; dark brown (10YR 4/3) moist; weak, thin, platy parting to weak fine subangular blocky structure; slightly hard, friable, nonsticky, slightly plastic; common fine, few medium roots; common fine vesicular and tubular pores; noncalcareous; clear smooth boundary.

B21t -- 8-12" -- Pale brown (10YR 6/3) light clay loam; brown (10YR 4/3) moist; weak, coarse, prismatic, parting to moderate, fine and medium subangular blocky structure; hard, firm, plastic and sticky; few fine and medium roots; many fine tubular pores; thin, nearly continuous clay films; noncalcareous; abrupt and smooth boundary.

B22t -- 12-15" -- Very pale brown (10YR 7/3) gravelly clay loam; brown (10YR 4/3) moist; moderate, fine, subangular blocky structure; hard, firm, sticky, and plastic; few fine and medium roots; common fine and medium tubular pores; thin, nearly continuous clay films; noncalcareous; abrupt smooth boundary.

C1ca -- 15-19" -- Very pale brown (10YR 7/3) gritty loam; dark yellowish brown (10YR 4/4) moist; weak, fine subangular blocky structure; soft, friable, nonsticky, nonplastic; few fine roots; few fine tubular pores; highly calcareous; many lime veins; clear wavy boundary.

C2ca -- 19-26" -- Light gray (10YR 7/2) sandy loam; yellowish brown (10YR 5/4) moist; white (10YR 8/2) lime veins; weak, medium platy, parting to weak fine subangular blocky structure; soft friable, nonsticky, nonplastic; few fine roots; common fine tubular pores; highly calcareous; many lime veins; gradual smooth boundary.

C3ca -- 26-34" -- Very pale brown (10YR 7/3) light sandy loam; weak, medium platy; parting to weak fine subangular blocky structure; soft, very friable, nonsticky, nonplastic; common fine roots; common fine tubular pores; moderately calcareous; few thick lime veins; clear smooth boundary.

C4 -- 34-38" -- Very pale brown (10YR 7/3) slightly gravelly sandy loam; yellowish brown (10YR 5/4) moist; weak, fine subangular blocky structure; soft, very friable, nonsticky, nonplastic; common fine roots; common fine tubular pores; moderately calcareous.

Table B3.--Summary of Dry Bulk Density Data for Flats.

Depth (inches)	Bulk Density (g/cc)[1/] Average	Range	No. of Samples
0-4	1.48	1.46-1.56	4
4-7	1.38	1.27-1.44	4
7-10	1.34	1.27-1.42	4
10-13	1.29	1.25-1.34	4
13-16	1.33	1.26-1.35	4
16-19	1.31	1.25-1.36	4
19-22	1.24	1.13-1.36	4
22-25	1.22	1.10-1.29	4

1/ Core Method

LOCATION - FLATS STATION NUMBER - 68057396 DATE - 07/1 2
TYPE OF RUN - ONE-DIMENSIONAL CAPACITY RUN NUMBER - 5
INTENSITY - 2.0 IN/HR LENGTH OF RUN - 135 MINUTES OPERATORS - M
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 6.36 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.04 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
12.	0.0	0.0	0.400	2.000
14.	0.013	0.550	0.453	1.450
16.	0.037	0.699	0.497	1.301
18.	0.060	0.649	0.540	1.351
20.	0.080	0.649	0.587	1.351
22.	0.103	0.699	0.630	1.301
24.	0.127	0.799	0.673	1.201
26.	0.157	0.799	0.710	1.201
28.	0.180	0.799	0.753	1.201
30.	0.210	0.849	0.790	1.151
32.	0.236	0.849	0.830	1.151
34.	0.266	0.849	0.867	1.151
36.	0.293	0.699	0.907	1.301
38.	0.313	0.749	0.954	1.251
40.	0.343	0.799	0.990	1.201
42.	0.366	0.699	1.034	1.301
44.	0.390	0.699	1.077	1.301
46.	0.413	0.699	1.120	1.301
48.	0.436	0.799	1.164	1.201
50.	0.466	0.849	1.200	1.151
52.	0.493	0.849	1.240	1.151
54.	0.523	0.999	1.277	1.001
56.	0.560	0.999	1.307	1.001
58.	0.590	0.899	1.344	1.101
60.	0.619	0.999	1.381	1.001
62.	0.656	0.999	1.411	1.001
64.	0.686	0.999	1.447	1.001
66.	0.723	0.949	1.477	1.051
68.	0.749	0.949	1.517	1.051
70.	0.786	1.149	1.547	0.851
72.	0.826	1.349	1.574	0.651
74.	0.876	1.299	1.591	0.701
76.	0.913	1.049	1.621	0.951
78.	0.946	1.099	1.654	0.901
80.	0.986	1.099	1.681	0.901
82.	1.019	1.099	1.714	0.901
84.	1.059	1.199	1.741	0.801
86.	1.099	1.149	1.768	0.851
88.	1.136	1.049	1.793	0.951

LOCATION - FLATS STATION NUMBER - 68057396 DATE - 07/17/72
TYPE OF RUN - ONE-DIMENSIONAL CAPACITY RUN NUMBER - 5
INTENSITY - 2.0 IN/HR LENGTH OF RUN - 135 MINUTES OPERATORS - MM;
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 6.36 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.04 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
90.	1.169	1.049	1.831	0.951
92.	1.206	1.099	1.861	0.901
94.	1.242	1.049	1.891	0.951
96.	1.276	0.999	1.924	1.001
98.	1.309	0.999	1.958	1.001
100.	1.342	0.999	1.991	1.001
102.	1.376	0.999	2.024	1.001
104.	1.409	1.099	2.058	0.901
106.	1.449	1.299	2.085	0.701
108.	1.495	1.349	2.105	0.651
110.	1.539	1.249	2.128	0.751
112.	1.579	1.149	2.155	0.851
114.	1.615	1.149	2.185	0.851
116.	1.655	1.199	2.211	0.801
118.	1.695	1.299	2.238	0.701
120.	1.742	1.149	2.258	0.851
122.	1.772	0.999	2.295	1.001
124.	1.808	1.199	2.325	0.801
126.	1.852	1.299	2.348	0.701
128.	1.895	1.199	2.372	0.801
130.	1.932	1.149	2.402	0.851
132.	1.972	1.199	2.428	0.801
134.	2.012	1.199	2.455	0.801
135.	2.032	1.199	2.468	0.801

LOCATION - FLATS STATION NUMBER - 68057396 DATE - 07/18
TYPE OF RUN - RETENTION RUN NUMBER - 6
INTENSITY - 2.0 IN/HR LENGTH OF RUN - 60 MINUTES OPERATORS - MM
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.35 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.42 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
2.	0.0	0.0	0.067	2.000
4.	0.017	0.600	0.117	1.400
6.	0.040	0.799	0.160	1.201
8.	0.070	1.099	0.197	0.901
10.	0.113	1.349	0.220	0.651
12.	0.160	1.349	0.240	0.651
14.	0.203	1.249	0.264	0.751
16.	0.243	1.299	0.290	0.701
18.	0.290	1.399	0.310	0.601
20.	0.336	1.499	0.330	0.501
22.	0.390	1.549	0.344	0.451
24.	0.440	1.449	0.360	0.551
26.	0.486	1.499	0.380	0.501
28.	0.540	1.499	0.394	0.501
30.	0.586	1.349	0.414	0.651
32.	0.629	1.399	0.437	0.601
34.	0.679	1.499	0.454	0.501
36.	0.729	1.549	0.471	0.451
38.	0.783	1.449	0.484	0.551
40.	0.826	1.399	0.507	0.601
42.	0.876	1.549	0.524	0.451
44.	0.929	1.449	0.537	0.551
46.	0.973	1.449	0.561	0.551
48.	1.026	1.499	0.574	0.501
50.	1.072	1.499	0.594	0.501
52.	1.126	1.599	0.608	0.401
54.	1.179	1.649	0.621	0.351
56.	1.236	1.649	0.631	0.351
58.	1.289	1.499	0.644	0.501
60.	1.336	1.399	0.664	0.601

LOCATION - FLATS   STATION NUMBER - 68057396   DATE - 07/18/72
TYPE OF RUN - RETENTION   RUN NUMBER - 7
INTENSITY - 4.0 IN/HR   LENGTH OF RUN - 30 MINUTES   OPERATORS - MM;
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.43 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.77 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
2.	0.0	0.0	0.133	4.000
4.	0.040	1.699	0.227	2.301
6.	0.113	2.698	0.287	1.302
8.	0.220	3.147	0.314	0.853
10.	0.323	3.147	0.344	0.853
12.	0.430	3.347	0.370	0.653
14.	0.546	3.397	0.387	0.603
16.	0.656	3.047	0.411	0.953
18.	0.749	2.948	0.451	1.052
20.	0.853	3.097	0.481	0.903
22.	0.956	2.948	0.511	1.052
24.	1.049	2.798	0.551	1.202
26.	1.142	2.848	0.591	1.152
28.	1.239	2.898	0.628	1.102
30.	1.336	2.898	0.664	1.102

LOCATION - FLATS STATION NUMBER - 68057396 DATE - 07/18/
TYPE OF RUN - RETENTION RUN NUMBER - 8
INTENSITY - 6.0 IN/HR LENGTH OF RUN - 20 MINUTES OPERATORS - MM,
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.77 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.98 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
1.	0.0	0.0	0.100	6.000
3.	0.093	3.747	0.207	2.253
5.	0.250	4.896	0.250	1.104
7.	0.420	5.096	0.280	0.904
9.	0.590	5.096	0.310	0.904
11.	0.759	5.096	0.341	0.904
13.	0.929	5.346	0.371	0.654
15.	1.116	5.246	0.384	0.754
17.	1.279	5.096	0.421	0.904
19.	1.455	5.396	0.445	0.604
20.	1.549	5.595	0.451	0.405

LOCATION - FLATS STATION NUMBER - 68057396 DATE - 07/18/72
TYPE OF RUN - RETENTION RUN NUMBER - 9
INTENSITY - 3.0 IN/HR LENGTH OF RUN - 40 MINUTES OPERATORS - MM
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.98 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.98 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
2.	0.0	0.0	0.100	3.000
4.	0.043	1.599	0.157	1.401
6.	0.107	2.148	0.193	0.852
8.	0.187	2.498	0.213	0.502
10.	0.273	2.498	0.227	0.502
12.	0.353	2.398	0.247	0.602
14.	0.433	2.398	0.267	0.602
16.	0.513	2.548	0.287	0.452
18.	0.603	2.498	0.297	0.502
20.	0.679	2.448	0.321	0.552
22.	0.766	2.598	0.334	0.402
24.	0.853	2.548	0.347	0.452
26.	0.936	2.498	0.364	0.502
28.	1.019	2.498	0.381	0.502
30.	1.102	2.498	0.398	0.502
32.	1.186	2.498	0.414	0.502
34.	1.269	2.448	0.431	0.552
36.	1.349	2.548	0.451	0.452
38.	1.439	2.548	0.461	0.452
40.	1.519	2.398	0.481	0.602

LOCATION - FLATS STATION NUMBER - 68057196 DATE - 07/28/72
TYPE OF RUN - ONE-DIMENSIONAL CAPACITY RUN NUMBER - 4
INTENSITY - 2.0 IN/HR LENGTH OF RUN - 136 MINUTES OPERATORS - MM,
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 6.48 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 7.90 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
6.	0.0	0.0	0.200	2.000
8.	0.027	0.849	0.240	1.151
10.	0.057	1.199	0.277	0.801
12.	0.107	1.399	0.293	0.601
14.	0.150	1.499	0.317	0.501
16.	0.206	1.649	0.327	0.351
18.	0.260	1.599	0.340	0.401
20.	0.313	1.649	0.354	0.351
22.	0.370	1.699	0.364	0.301
24.	0.426	1.649	0.374	0.351
26.	0.480	1.699	0.387	0.301
28.	0.540	1.799	0.394	0.201
30.	0.600	1.848	0.400	0.152
32.	0.663	1.699	0.404	0.301
34.	0.713	1.599	0.421	0.401
36.	0.769	1.848	0.431	0.152
38.	0.836	1.699	0.431	0.301
40.	0.883	1.549	0.451	0.451
42.	0.939	1.599	0.461	0.401
44.	0.989	1.499	0.477	0.501
46.	1.039	1.699	0.494	0.301
48.	1.102	1.699	0.498	0.301
50.	1.152	1.649	0.514	0.351
52.	1.212	1.799	0.521	0.201
54.	1.272	1.749	0.528	0.251
56.	1.329	1.848	0.538	0.152
58.	1.396	1.948	0.538	0.052
60.	1.459	1.799	0.541	0.201
62.	1.515	1.699	0.551	0.301
64.	1.572	1.699	0.561	0.301
66.	1.629	1.649	0.571	0.351
68.	1.682	1.799	0.585	0.201
70.	1.749	1.948	0.585	0.052
72.	1.812	1.848	0.588	0.152
74.	1.872	1.799	0.595	0.201
76.	1.932	1.798	0.602	0.202
78.	1.992	1.599	0.608	0.401
80.	2.038	1.399	0.628	0.601
82.	2.085	1.499	0.648	0.501

LOCATION - FLATS STATION NUMBER - 68057196 DATE - 07/28/72
TYPE OF RUN - ONE-DIMENSIONAL CAPACITY RUN NUMBER - 4
INTENSITY - 2.0 IN/HR LENGTH OF RUN - 136 MINUTES OPERATORS - MM,
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 6.48 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 7.90 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
84.	2.138	1.799	0.662	0.201
86.	2.205	1.848	0.662	0.152
88.	2.261	1.699	0.672	0.301
90.	2.318	1.699	0.682	0.301
92.	2.375	1.699	0.692	0.301
94.	2.431	1.699	0.702	0.301
96.	2.488	1.699	0.712	0.301
98.	2.545	1.649	0.722	0.351
100.	2.598	1.549	0.735	0.451
102.	2.648	1.649	0.752	0.351
104.	2.708	1.798	0.759	0.202
106.	2.768	1.799	0.766	0.201
108.	2.828	1.699	0.772	0.301
110.	2.881	1.649	0.786	0.351
112.	2.938	1.649	0.796	0.351
114.	2.991	1.549	0.809	0.451
116.	3.041	1.549	0.826	0.451
118.	3.094	1.649	0.839	0.351
120.	3.151	1.749	0.849	0.251
122.	3.211	1.749	0.856	0.251
124.	3.267	1.749	0.866	0.251
126.	3.327	1.848	0.873	0.152
128.	3.391	1.549	0.876	0.451
130.	3.430	1.499	0.903	0.501
132.	3.490	1.798	0.910	0.202
134.	3.550	1.649	0.916	0.351
136.	3.600	1.499	0.933	0.501

LOCATION - FLATS   STATION NUMBER - 68057196   DATE - 07/25/
TYPE OF RUN - RETENTION   RUN NUMBER - 6
INTENSITY - 2.0 IN/HR   LENGTH OF RUN - 60 MINUTES   OPERATORS - MM
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 7.75 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.26 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
3.	0.0	0.0	0.100	2.000
5.	0.040	1.299	0.127	0.701
7.	0.087	1.699	0.147	0.301
9.	0.153	1.948	0.147	0.052
11.	0.216	1.848	0.150	0.152
13.	0.276	1.848	0.157	0.152
15.	0.340	1.799	0.160	0.201
17.	0.396	1.749	0.170	0.251
19.	0.456	1.799	0.177	0.201
21.	0.516	1.798	0.184	0.202
23.	0.576	1.798	0.190	0.202
25.	0.636	1.799	0.197	0.201
27.	0.696	1.799	0.204	0.201
29.	0.756	1.848	0.211	0.152
31.	0.819	1.848	0.214	0.152
33.	0.879	1.848	0.221	0.152
35.	0.943	1.848	0.224	0.152
37.	1.002	1.749	0.231	0.251
39.	1.059	1.848	0.241	0.152
41.	1.126	1.898	0.241	0.102
43.	1.186	1.749	0.248	0.251
45.	1.242	1.699	0.258	0.301
47.	1.299	1.799	0.268	0.201
49.	1.362	1.948	0.271	0.052
51.	1.429	1.848	0.271	0.152
53.	1.485	1.848	0.281	0.152
55.	1.552	1.848	0.281	0.152
57.	1.609	1.699	0.291	0.301
59.	1.665	1.665	0.301	0.335
60.	1.692	1.599	0.308	0.401

LOCATION - FLATS STATION NUMBER - 68057196 DATE - 07/25/72
TYPE OF RUN - RETENTION RUN NUMBER - 7
INTENSITY - 2.67 IN/HR LENGTH OF RUN - 45 MINUTES OPERATORS - MM
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.33 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.40 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
3.	0.0	0.0	0.133	2.670
5.	0.063	2.148	0.159	0.522
7.	0.143	2.498	0.168	0.172
9.	0.230	2.498	0.171	0.172
11.	0.310	2.498	0.180	0.172
13.	0.396	2.498	0.182	0.172
15.	0.476	2.498	0.191	0.172
17.	0.563	2.448	0.194	0.222
19.	0.639	2.448	0.206	0.222
21.	0.726	2.498	0.208	0.172
23.	0.806	2.498	0.218	0.172
25.	0.893	2.498	0.220	0.172
27.	0.973	2.448	0.229	0.222
29.	1.056	2.548	0.235	0.122
31.	1.142	2.648	0.237	0.022
33.	1.232	2.598	0.235	0.072
35.	1.316	2.598	0.242	0.072
37.	1.405	2.598	0.241	0.072
39.	1.489	2.498	0.247	0.172
41.	1.572	2.498	0.252	0.172
43.	1.655	2.398	0.258	0.272
45.	1.732	2.298	0.271	0.372

Table 64.--Soil Profile Description for Nancy

Location - Nancy
Soil Name - Babbington loam
Classification - Fine-loamy, mixed, mesic family of Aridic Calcic Argixerolls
Natural Vegetation - Big sagebrush, bluebunch wheatgrass, squirrel tail, Sandberg bluegrass
Climate - 11 to 12 inches mean annual precipitation; mesic, but marginal to frigid temperature regime
Parent Material - Residuum from basalt, possibly some loess in the surface horizons.
Physiography - Dissected basalt plateau
Relief - Gently rolling
Slope - 4 percent, east facing
Elevation - About 4400 feet
Drainage - Well drained; ground water very deep
Stoniness - Few surface stones and some stones throughout the profile
Erosion - Moderate
Permeability - Moderately slow

Profile Description - (Colors are for dry soil unless noted otherwise.)

A1 -- 0-3" -- Brown (10YR 5/3) loam; very dark grayish brown (10YR 3/2) moist; weak, coarse, platy; parting to weak fine granular structure; slightly hard, very friable, slightly sticky, slightly plastic; many fine few medium and coarse roots; many fine and medium pores; noncalcareous; clear smooth boundary.

B1 -- 3-6" -- Pale brown (10YR slightly gravelly heavy loam; dark brown (10YR 3/3) moist; weak thin platy, parting to moderate very fine subangular blocky structure; slightly hard, friable, slightly plastic; many fine few medium and coarse roots; many fine interstitial pores; noncalcareous; clear smooth boundary.

B21t -- 6-12" -- Brown (10YR 5/3) clay loam; dark brown (10YR 3/3) moist; strong fine subangular blocky structure; hard, firm, sticky, plastic; common fine few medium and coarse roots; many fine and medium interstitial and tubular pores; thin nearly continuous clay films; noncalcareous; gradual smooth boundary.

B22t -- 12-20" -- Yellowish brown (10YR 5/4) slightly gravelly heavy clay loam; dark brown (10YR 3/3) moist; weak medium prismatic parting to moderate fine subangular blocky structure; hard, firm, sticky, plastic; common fine few medium and coarse roots; common fine few medium tubular pores; thin continuous clay film; noncalcareous; clear smooth boundary.

B3ca -- 20-28" -- Light yellowish brown (10YR 6/4) gravelly clay loam; dark yellowish brown (10YR 4/4) moist; moderate medium and fine subangular blocky structure; hard, firm, sticky, and plastic; few fine and medium roots; common fine tubular pores; thin nearly

continuous clay films; moderately calcareous with common lime veins that are highly calcareous; clear smooth boundary.

C1ca -- 28-38" -- Light yellowish brown (10YR 6/4) gravelly loam; yellowish brown (10YR 5/4) moist; moderate fine subangular blocky structure; hard, friable, nonsticky, slightly plastic; few fine roots; few fine tubular pores; moderately calcareous with many lime veins which are highly calcareous; abrupt smooth boundary.

C2ca R -- 38-44" -- Variegated colors consisting of yellowish brown (10YR 5/4) to white (10YR 8/1) very stony gravelly coarse sand with large fragments of basalt bedrock; dark yellowish brown (10YR 3/4) to very pale brown (10YR 8/3) moist; many lime veins which are highly calcareous; basalt fragments are strongly weathered; a thin root mat is on the top of this horizon.

Table B5.--Summary of Dry Bulk Density Data for Nancy.

Depth (inches)	Bulk Density (g/cc)[1/] Average	Range	No. of Samples
0-4	1.23	1.26-1.23	2
4-7	1.22	1.18-1.26	2
7-10	1.24	1.11-1.36	2
10-13	1.24	1.17-1.30	2
13-16	1.24	1.20-1.28	2
16-19	1.26	1.23-1.29	2
19-22	1.15	1.13-1.18	2
22-25	1.11	1.10-1.12	2
25-28	1.00	1.00-1.00	2

1/ Core Method

LOCATION - HANCEY'S STATION NUMBER - 68098Y97 DATE - 08/07/72
TYPE OF RUN - ONE-DIMENSIONAL CAPACITY RUN NUMBER - 3
INTENSITY - 2.5 IN/HR LENGTH OF RUN - 131 MINUTES OPERATORS - GW,
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 3.18 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 5.45 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
10.	0.0	0.0	0.417	2.500
12.	0.017	0.450	0.483	2.050
14.	0.030	0.500	0.553	2.000
16.	0.050	0.550	0.617	1.950
18.	0.067	0.699	0.683	1.801
20.	0.097	0.849	0.737	1.651
22.	0.123	0.699	0.793	1.801
24.	0.143	0.849	0.857	1.651
26.	0.180	0.999	0.903	1.501
28.	0.210	0.999	0.957	1.501
30.	0.246	0.999	1.004	1.501
32.	0.276	0.899	1.057	1.601
34.	0.306	1.099	1.110	1.401
36.	0.350	1.199	1.150	1.301
38.	0.386	1.249	1.197	1.251
40.	0.433	1.349	1.234	1.151
42.	0.476	1.449	1.274	1.051
44.	0.530	1.499	1.304	1.001
46.	0.576	1.399	1.340	1.101
48.	0.623	1.499	1.377	1.001
50.	0.676	1.499	1.407	1.001
52.	0.723	1.499	1.444	1.001
54.	0.776	1.793	1.474	0.702
56.	0.843	1.699	1.491	0.801
58.	0.889	1.499	1.527	1.001
60.	0.943	1.599	1.557	0.901
62.	0.996	1.499	1.587	1.001
64.	1.042	1.499	1.624	1.001
66.	1.096	1.649	1.654	0.851
68.	1.152	1.699	1.681	0.801
70.	1.209	1.649	1.708	0.851
72.	1.262	1.649	1.738	0.851
74.	1.319	1.699	1.764	0.801
76.	1.376	1.848	1.791	0.652
78.	1.442	1.799	1.808	0.701
80.	1.495	1.599	1.838	0.901
82.	1.549	1.649	1.868	0.851
84.	1.605	1.599	1.895	0.901
86.	1.655	1.599	1.928	0.901

LOCATION - YANCEY'S STATION NUMBER - 68098Y97 DATE - 08/07/72
TYPE OF RUN - ONE-DIMENSIONAL CAPACITY RUN NUMBER - 3
INTENSITY - 2.5 IN/HR LENGTH OF RUN - 131 MINUTES OPERATORS - GW;
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 3.18 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 5.45 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
88.	1.712	1.848	1.955	0.652
90.	1.779	1.799	1.971	0.701
92.	1.832	1.549	2.002	0.951
94.	1.882	1.649	2.035	0.851
96.	1.942	1.749	2.058	0.751
98.	1.998	1.649	2.085	0.851
100.	2.052	1.699	2.115	0.801
102.	2.112	1.649	2.138	0.851
104.	2.162	1.599	2.172	0.901
106.	2.213	1.699	2.199	0.801
108.	2.275	1.649	2.225	0.851
110.	2.328	1.649	2.255	0.851
112.	2.385	1.699	2.282	0.801
114.	2.441	1.898	2.309	0.602
116.	2.511	1.848	2.322	0.652
118.	2.565	1.799	2.352	0.701
120.	2.631	1.749	2.369	0.751
122.	2.681	1.599	2.402	0.901
124.	2.738	1.848	2.429	0.652
126.	2.804	1.948	2.446	0.552
128.	2.868	1.699	2.466	0.801
130.	2.918	1.549	2.499	0.951
131.	2.971	1.932	2.529	0.568
~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~

LOCATION - NANCEY'S STATION NUMBER - 68098Z97 DATE - 08/15/72
TYPE OF RUN - ONE-DIMENSION CAPACITY RUN NUMBER - 2
INTENSITY - 2.0 IN/HR LENGTH OF RUN - 135 MINUTES OPERATORS - MN,
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 7.08 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.54 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
8.	0.0	0.0	0.267	2.000
10.	0.013	0.400	0.320	1.600
12.	0.027	0.300	0.373	1.700
14.	0.033	0.350	0.433	1.650
16.	0.050	0.500	0.483	1.500
18.	0.067	0.450	0.533	1.550
20.	0.080	0.400	0.587	1.600
22.	0.093	0.500	0.640	1.500
24.	0.113	0.600	0.687	1.400
26.	0.133	0.600	0.733	1.400
28.	0.153	0.600	0.780	1.400
30.	0.173	0.649	0.827	1.351
32.	0.197	0.699	0.870	1.301
34.	0.220	0.649	0.914	1.351
36.	0.240	0.699	0.960	1.301
38.	0.266	0.749	1.000	1.251
40.	0.290	0.699	1.044	1.301
42.	0.313	0.649	1.087	1.351
44.	0.333	0.649	1.134	1.351
46.	0.356	0.749	1.177	1.251
48.	0.383	0.749	1.217	1.251
50.	0.406	0.749	1.260	1.251
52.	0.433	0.749	1.300	1.251
54.	0.456	0.649	1.344	1.351
56.	0.476	0.649	1.390	1.351
58.	0.500	0.749	1.434	1.251
60.	0.526	0.799	1.474	1.201
62.	0.553	0.749	1.514	1.251
64.	0.576	0.749	1.557	1.251
66.	0.603	0.849	1.597	1.151
68.	0.633	0.799	1.634	1.201
70.	0.656	0.749	1.677	1.251
72.	0.683	0.699	1.717	1.301
74.	0.703	0.649	1.764	1.351
76.	0.726	0.749	1.807	1.251
78.	0.753	0.749	1.847	1.251
80.	0.776	0.849	1.891	1.151
82.	0.809	0.849	1.924	1.151
84.	0.833	0.799	1.967	1.201

LOCATION - NANCEY'S STATION NUMBER - 68098Z97 DATE - 08/15/
TYPE OF RUN - ONE-DIMENSION CAPACITY RUN NUMBER - 2
INTENSITY - 2.0 IN/HR LENGTH OF RUN - 135 MINUTES OPERATORS - MM
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 7.08 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.54 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
86.	0.863	0.849	2.004	1.151
88.	0.889	0.849	2.044	1.151
90.	0.919	0.849	2.081	1.151
92.	0.946	0.899	2.121	1.101
94.	0.979	0.849	2.154	1.151
96.	1.002	0.799	2.198	1.201
98.	1.032	0.949	2.234	1.051
100.	1.066	0.949	2.268	1.051
102.	1.096	0.899	2.304	1.101
104.	1.126	0.899	2.341	1.101
106.	1.156	0.899	2.378	1.101
108.	1.186	0.899	2.414	1.101
110.	1.216	0.849	2.451	1.151
112.	1.242	0.899	2.491	1.101
114.	1.276	0.949	2.524	1.051
116.	1.306	0.849	2.561	1.151
118.	1.332	0.899	2.601	1.101
120.	1.366	0.999	2.634	1.001
122.	1.399	1.049	2.668	0.951
124.	1.435	1.099	2.698	0.901
126.	1.472	0.999	2.728	1.001
128.	1.502	0.899	2.765	1.101
130.	1.532	0.949	2.801	1.051
132.	1.565	0.949	2.835	1.051
134.	1.595	0.999	2.871	1.001
135.	1.615	1.199	2.885	0.801

LOCATION - NANCEY'S STATION NUMBER - 68098Z97 DATE - 08/15/72
TYPE OF RUN - RETENTION RUN NUMBER - 6
INTENSITY - 2.0 IN/HR LENGTH OF RUN - 60 MINUTES OPERATORS - MM;
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 7.87 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.16 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
5.	0.0	0.0	0.167	2.000
7.	0.017	0.600	0.217	1.400
9.	0.040	0.749	0.260	1.251
11.	0.067	0.899	0.300	1.101
13.	0.100	1.099	0.333	0.901
15.	0.140	1.249	0.360	0.751
17.	0.183	1.299	0.383	0.701
19.	0.226	1.299	0.407	0.701
21.	0.270	1.299	0.430	0.701
23.	0.313	1.299	0.454	0.701
25.	0.356	1.299	0.477	0.701
27.	0.400	1.299	0.500	0.701
29.	0.443	1.299	0.524	0.701
31.	0.486	1.299	0.547	0.701
33.	0.530	1.299	0.570	0.701
35.	0.573	1.349	0.594	0.651
37.	0.619	1.249	0.614	0.751
39.	0.656	1.299	0.644	0.701
41.	0.706	1.399	0.661	0.601
43.	0.749	1.349	0.684	0.651
45.	0.796	1.399	0.704	0.601
47.	0.843	1.299	0.724	0.701
49.	0.883	1.149	0.751	0.851
51.	0.919	1.299	0.781	0.701
53.	0.959	1.299	0.797	0.701
55.	1.006	1.249	0.828	0.751
57.	1.052	1.399	0.843	0.601
59.	1.099	1.332	0.868	0.668
60.	1.119	1.199	0.881	0.801

LOCATION - HANCEY'S STATION NUMBER - 68098Z97 DATE - 08/15/72
TYPE OF RUN - RETENTION RUN NUMBER - 7
INTENSITY - 2.67 IN/HR LENGTH OF RUN - 45 MINUTES OPERATORS - MM,
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.16 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.38 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
4.	0.0	0.0	0.178	2.670
6.	0.033	1.099	0.234	1.571
8.	0.073	1.399	0.283	1.271
10.	0.127	1.699	0.318	0.971
12.	0.187	1.898	0.347	0.772
14.	0.253	1.998	0.370	0.672
16.	0.320	1.998	0.392	0.672
18.	0.386	2.098	0.415	0.572
20.	0.460	2.048	0.430	0.622
22.	0.523	1.749	0.456	0.921
24.	0.575	1.898	0.492	0.772
26.	0.649	2.148	0.508	0.522
28.	0.719	2.548	0.527	0.122
30.	0.819	2.498	0.516	0.172
32.	0.886	2.048	0.538	0.622
34.	0.956	1.998	0.557	0.672
36.	1.019	1.898	0.583	0.772
38.	1.082	1.998	0.609	0.672
40.	1.152	2.048	0.628	0.622
42.	1.219	2.048	0.650	0.622
44.	1.289	2.065	0.669	0.605
45.	1.322	1.998	0.680	0.672

LOCATION - NANCEY'S STATION NUMBER - 68098Z97 DATE - 08/15/72
TYPE OF RUN - RETENTION RUN NUMBER - 8
INTENSITY - 4.0 IN/HR LENGTH OF RUN - 30 MINUTES OPERATORS - MM
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.38 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.78 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
3.	0.0	0.0	0.200	4.000
5.	0.087	2.748	0.247	1.252
7.	0.183	3.097	0.283	0.903
9.	0.293	3.347	0.307	0.653
11.	0.406	3.397	0.327	0.603
13.	0.520	3.397	0.347	0.603
15.	0.633	3.347	0.367	0.653
17.	0.743	3.297	0.391	0.703
19.	0.853	3.297	0.414	0.703
21.	0.963	3.197	0.437	0.803
23.	1.066	3.247	0.468	0.753
25.	1.179	3.497	0.488	0.503
27.	1.299	3.397	0.501	0.603
29.	1.405	3.331	0.528	0.669
30.	1.465	3.597	0.535	0.403

LOCATION - NANCEY'S STATION NUMBER - 63098Z97 DATE - 08/15/
TYPE OF RUN - RETENTION RUN NUMBER - 9
INTENSITY - 8.0 IN/HR LENGTH OF RUN - 15 MINUTES OPERATORS - MM
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.78 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.05 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
2.	0.0	0.0	0.267	8.000
4.	0.230	7.194	0.304	0.806
6.	0.480	7.344	0.320	0.656
8.	0.719	7.294	0.347	0.706
10.	0.966	7.394	0.367	0.606
12.	1.212	7.444	0.388	0.556
14.	1.462	7.460	0.405	0.540
15.	1.585	7.394	0.415	0.606

Table B6.--Soil Profile Description for Lower Sheep

Location - Lower Sheep
Soil Name - Searla Gravelly loam
Classification - Not known
Natural Vegetation - Sagebrush (arbuscula) and grass
Climate - 11 to 12 inches mean annual precipitation; mesic, but marginal to frigid temperature regime.
Parent Material - Rhyolite
Physiography - Alluvial fan
Relief - Gently rolling
Slope - 0-30%
Elevation - 4600 feet
Drainage - Well drained; ground water very deep
Stoniness - Few surface stones and some stones throughout the profile
Erosion - Moderate
Permeability - Moderately slow

Profile Description - (Colors are for dry soil unless noted otherwise.)

A11 — 0-3" -- Grayish-brown (10YR 5/2) very (angular) gravelly loam, very dark grayish brown (10YR 3/2) when moist; weak, very thin platy, parting to weak, very fine granular structure; slightly hard, very friable, slightly sticky, slightly plastic; abundant very fine and fine roots; many micro interstitial and few very fine vesicular pores; neutral reaction (pH 6.6 bromthymol blue); clear, smooth boundary.

A12 — 3-9" -- Dark grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2) (10YR 5/2 when rubbed) very (angular) gravelly loam, very dark brown (10YR 2/2) (10YR 3/2 when rubbed) when moist; weak, fine and medium, subangular blocky, parting to weak, very fine granular structure; slightly hard, very friable, slightly sticky, slightly plastic; abundant very fine and fine roots; many micro interstitial pores; neutral reaction (pH 6.6 btb); clear, wavy boundary.

B1t — 9-15" — Brown (10YR 5/2) and dark grayish-brown (10YR 4/2), channery or very channery, heavy loam or light clay loam, which is grayish brown (10YR 5/2) when rubbed; dark brown (10YR 3/3) and very dark brown (10YR 2/2) (10YR 3/3 when rubbed) when moist; moderate or weak, fine and very fine, subangular blocky, parting to weak, very fine and fine granular structure when dry; slightly hard, friable, slightly sticky, slightly plastic; plentiful very fine and fine roots; many very fine tubular pores; thin patchy clay films on peds and in pores; neutral reaction (pH 6.8 btb); clear, wavy boundary.

B21t — 15-24" — Brown (10YR 5/3) very channery clay loam; more than 50 percent of coarse fragments of channery fragments, angular gravel, and few flagstones; dark brown (10YR 4/3) when moist; moderate, fine and very fine, subangular blocky structure; hard, firm, sticky, plastic; plentiful fine and very fine roots; common very

fine tubular pores; thin, patchy clay films on peds and in pores; noncalcareous; mildly alkaline (pH 7.7 btb); clear, wavy boundary.

B22t -- 24-38" -- Brown (10YR 5/3) very channery clay loam; more than 50 percent of coarse fragments of channery fragments. angular gravel, and few fragstones; dark brown (10YR 4/3) when moist; moderate, fine and very fine, fubangular blocky structure; hard, firm, sticky, plastic; few fine roots; common very fine tubular pores; thin, nearly continuous clay films on peds and in pores; mostly noncalcareous but few thin veins and spots of lime on sides and underside of recks and slightly calcareous soil adjoining the rocks; mildly alkaline (pH 7.8 cresol red); clear, wavy boundary.

B3tca -- 38-49" -- Brown (10YR 5/3) very channery clay loam; 50 percent of coarse fragments of channery fragments, angular gravel, and few flagstones; brown (10YR 4/3) when moist; moderate, very fine and fine, subangular blocky and weak, fine and medium granular structure; hard, friable, sticky, plastic; few fine roots; common very fine tubular pores; thin, nearly continuous clay films on peds and in pores; few veins, spots, and coatings of lime on rocks but most of the soil material is noncalcareous; moderately alkaline (pH 8.2 cr); clear, wavy boundary.

Cca -- 49-60" -- Pale-brown (10YR 6/3) very channery loam, brown (10YR 4/3) when moist; structureless, massive; hard, friable, slightly sticky, slightly plastic; few fine roots; few very fine tubular pores; lime veins, splotches, and coatings on the rock fragments and in the soil material adjacent to the coarse fragments; milkly alkaline (pH 8.2 cr). The coarse fragments are rhyolitic.

Table B7.--Summary of Dry Bulk Density Data for Lower Sheep Creek

Depth (inches)	Bulk Density (g/cc)1/ Average	Range	No. of Samples
0-4	1.16	1.04-1.21	6
4-7	1.16	0.43-1.37	6
7-10	1.13	0.97-1.33	6
10-13	1.14	1.04-1.33	6
13-16	1.09	0.94-1.45	6
16-19	1.09	1.01-1.19	6
19-22	1.13	0.94-1.20	5
22-25	1.24	1.16-1.32	2

1/ Core Method

LOCATION - LOWER SHEEP STATION NUMBER - 68127F07 DATE - 08/29/
TYPE OF RUN - RETENTION RUN NUMBER - 6
INTENSITY - 2.0 IN/HR LENGTH OF RUN - 60 MINUTES OPERATORS - MM,
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.14 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.28 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
7.	0.0	0.0	0.233	2.000
9.	0.013	0.550	0.287	1.450
11.	0.037	0.799	0.330	1.201
13.	0.067	1.049	0.367	0.951
15.	0.107	1.249	0.393	0.751
17.	0.150	1.249	0.417	0.751
19.	0.190	1.199	0.443	0.801
21.	0.230	1.199	0.470	0.801
23.	0.270	1.199	0.497	0.801
25.	0.310	1.199	0.524	0.801
27.	0.350	1.199	0.550	0.801
29.	0.390	1.299	0.577	0.701
31.	0.436	1.299	0.597	0.701
33.	0.476	1.299	0.624	0.701
35.	0.523	1.349	0.644	0.651
37.	0.566	1.299	0.667	0.701
39.	0.609	1.349	0.691	0.651
41.	0.656	1.299	0.711	0.701
43.	0.696	1.299	0.737	0.701
45.	0.743	1.299	0.757	0.701
47.	0.783	1.249	0.784	0.751
49.	0.826	1.299	0.807	0.701
51.	0.869	1.249	0.831	0.751
53.	0.909	1.249	0.857	0.751
55.	0.953	1.199	0.881	0.801
57.	0.989	1.299	0.911	0.701
59.	1.039	1.399	0.928	0.601
60.	1.059	1.199	0.941	0.801

LOCATION - LOWER SHEEP STATION NUMBER - 68127F07 DATE - 08/29/72
TYPE OF RUN - RETENTION RUN NUMBER - 7
INTENSITY - 2.67 IN/HR LENGTH OF RUN - 45 MINUTES OPERATORS - MM
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.28 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.28 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
4.	0.0	0.0	0.178	2.670
6.	0.020	0.699	0.247	1.971
8.	0.047	0.949	0.309	1.721
10.	0.083	1.199	0.362	1.471
12.	0.127	1.399	0.407	1.271
14.	0.177	1.649	0.446	1.021
16.	0.236	1.749	0.476	0.921
18.	0.293	1.649	0.508	1.021
20.	0.346	1.699	0.544	0.971
22.	0.406	1.699	0.573	0.971
24.	0.460	1.649	0.608	1.021
26.	0.516	1.749	0.641	0.921
28.	0.576	1.699	0.670	0.971
30.	0.629	1.699	0.706	0.971
32.	0.689	1.848	0.735	0.822
34.	0.753	1.749	0.760	0.921
36.	0.806	1.749	0.796	0.921
38.	0.869	1.798	0.822	0.872
40.	0.926	1.799	0.854	0.871
42.	0.989	1.799	0.880	0.871
44.	1.046	1.732	0.912	0.938
45.	1.076	1.798	0.927	0.872

LOCATION - LOWER SHEEP STATION NUMBER - 68127F07 DATE - 08/29/72
TYPE OF RUN - RETENTION RUN NUMBER - 8
INTENSITY - 4.0 IN/HR LENGTH OF RUN - 30 MINUTES OPERATORS - M
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.28 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.28 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
3.	0.0	0.0	0.200	4.000
5.	0.027	1.099	0.307	2.901
7.	0.073	1.699	0.393	2.301
9.	0.140	2.398	0.460	1.602
11.	0.233	2.898	0.500	1.102
13.	0.333	2.948	0.534	1.052
15.	0.430	2.898	0.570	1.102
17.	0.526	2.948	0.607	1.052
19.	0.626	2.997	0.641	1.003
21.	0.726	2.998	0.674	1.002
23.	0.826	2.998	0.707	1.002
25.	0.926	2.998	0.741	1.002
27.	1.026	2.998	0.774	1.002
29.	1.126	3.131	0.808	0.869
30.	1.182	3.397	0.818	0.603

LOCATION - LOWER SHEEP , STATION NUMBER - 68127F07 DATE - 08/29/72
TYPE OF RUN - RETENTION RUN NUMBER -9
INTENSITY - 8.0 IN/HR LENGTH OF RUN - 15 MINUTES OPERATORS - M
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.28 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 9.28 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
1.	0.0	0.0	0.133	8.000
3.	0.177	5.296	0.223	2.704
5.	0.353	5.246	0.314	2.754
7.	0.526	5.196	0.407	2.804
9.	0.699	5.196	0.501	2.804
11.	0.873	5.246	0.594	2.754
13.	1.049	5.296	0.684	2.704
15.	1.226	5.296	0.774	2.704

ATION - LOWER SHEEP STATION NUMBER - 68127F07 DATE - 08/2[illegible]2
TYPE OF RUN - ONE-DIMENSIONAL CAPACITY RUN NUMBER - 2
INTENSITY - 3.0 IN/HR LENGTH OF RUN - 180 MINUTES OPERATORS - M.
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 7.44 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.88 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
5.	0.0	0.0	0.250	3.000
7.	0.003	0.100	0.347	2.900
9.	0.007	0.100	0.443	2.900
11.	0.010	0.100	0.540	2.900
13.	0.013	0.050	0.637	2.950
15.	0.013	0.050	0.737	2.950
17.	0.017	0.100	0.833	2.900
19.	0.020	0.100	0.930	2.900
21.	0.023	0.100	1.027	2.900
23.	0.027	0.150	1.123	2.850
25.	0.033	0.200	1.217	2.800
27.	0.040	0.250	1.310	2.750
29.	0.050	0.300	1.400	2.700
31.	0.060	0.300	1.490	2.700
33.	0.070	0.500	1.580	2.500
35.	0.093	0.649	1.657	2.351
37.	0.113	0.649	1.737	2.351
39.	0.137	0.799	1.813	2.201
41.	0.167	0.899	1.883	2.101
43.	0.197	0.949	1.953	2.051
45.	0.230	1.049	2.020	1.951
47.	0.266	1.149	2.084	1.851
49.	0.306	1.299	2.144	1.701
51.	0.353	1.449	2.197	1.551
53.	0.403	1.399	2.247	1.601
55.	0.446	1.399	2.304	1.601
57.	0.496	1.499	2.354	1.501
59.	0.546	1.499	2.404	1.501
61.	0.596	1.599	2.454	1.401
63.	0.653	1.699	2.497	1.301
65.	0.709	1.699	2.541	1.301
67.	0.766	1.649	2.584	1.351
69.	0.819	1.699	2.631	1.301
71.	0.879	1.749	2.671	1.251
73.	0.936	1.749	2.714	1.251
75.	0.996	1.749	2.754	1.251
77.	1.052	1.749	2.798	1.251
79.	1.112	1.799	2.838	1.201
81.	1.172	1.848	2.878	1.152

ATION - LOWER SHEEP STATION NUMBER - 68127F07 DATE - 08/29/72
TYPE OF RUN - ONE-DIMENSIONAL CAPACITY RUN NUMBER - 2
INTENSITY - 3.0 IN/HR LENGTH OF RUN - 180 MINUTES OPERATORS - M
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 7.44 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.88 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
83.	1.236	1.898	2.914	1.102
85.	1.299	1.848	2.951	1.152
87.	1.359	1.848	2.991	1.152
89.	1.422	1.948	3.028	1.052
91.	1.489	1.948	3.061	1.052
93.	1.552	1.848	3.098	1.152
95.	1.612	1.848	3.138	1.152
97.	1.675	1.898	3.175	1.102
99.	1.739	1.898	3.211	1.102
101.	1.802	1.898	3.248	1.102
103.	1.865	1.898	3.285	1.102
105.	1.928	1.848	3.322	1.152
107.	1.988	1.848	3.362	1.152
109.	2.052	1.898	3.398	1.102
111.	2.115	1.898	3.435	1.102
113.	2.178	1.898	3.472	1.102
115.	2.241	1.898	3.509	1.102
117.	2.305	1.898	3.545	1.102
119.	2.368	1.898	3.582	1.102
121.	2.431	1.898	3.619	1.102
123.	2.495	1.898	3.655	1.102
125.	2.558	1.898	3.692	1.102
127.	2.621	1.898	3.729	1.102
129.	2.684	1.948	3.766	1.052
131.	2.751	1.948	3.799	1.052
133.	2.814	1.898	3.836	1.102
135.	2.878	1.898	3.872	1.102
137.	2.941	1.898	3.909	1.102
139.	3.004	1.898	3.946	1.102
141.	3.067	1.948	3.983	1.052
143.	3.134	1.948	4.016	1.052
145.	3.197	1.948	4.053	1.052
147.	3.264	1.998	4.086	1.002
149.	3.331	1.998	4.119	1.002
151.	3.397	1.948	4.153	1.052
153.	3.460	1.898	4.190	1.102
155.	3.524	1.948	4.226	1.052
157.	3.590	1.948	4.260	1.052
159.	3.654	1.898	4.296	1.102
161.	3.717	1.948	4.333	1.052

ATION - LOWER SHEEP STATION NUMBER - 68127F07 DATE - 08/2 2
TYPE OF RUN - ONE-DIMENSIONAL CAPACITY RUN NUMBER - 2
INTENSITY - 3.0 IN/HR LENGTH OF RUN - 180 MINUTES OPERATORS - H
INITIAL SOIL MOISTURE IN THE TOP 24 INCHES = 7.44 INCHES
FINAL SOIL MOISTURE IN THE TOP 24 INCHES = 8.88 INCHES

TIME FROM START OF RAIN (MINUTES)	ACCUMULATED RUNOFF (INCHES)	RUNOFF RATE (IN/HR)	ACCUMULATED INFILTRATION (INCHES)	INFILTRATION RATE (IN/HR)
163.	3.784	1.948	4.366	1.052
165.	3.847	1.948	4.403	1.052
167.	3.913	1.998	4.437	1.002
169.	3.980	2.048	4.470	0.952
171.	4.050	2.098	4.500	0.902
173.	4.120	2.098	4.530	0.902
175.	4.190	2.048	4.560	0.952
177.	4.256	1.948	4.594	1.052
179.	4.320	1.865	4.630	1.135
180.	4.350	1.798	4.650	1.202